

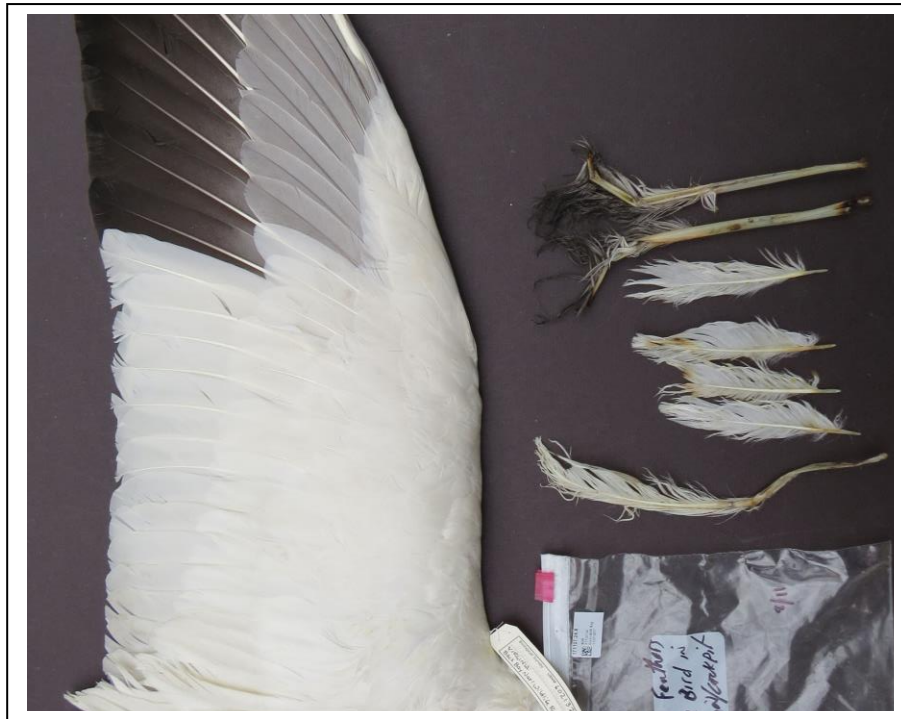


**U. S. DEPARTMENT
OF TRANSPORTATION
FEDERAL AVIATION
ADMINISTRATION**

Wildlife Strikes to Civil Aircraft in the United States 1990–2017



**U. S. DEPARTMENT
OF AGRICULTURE
WILDLIFE SERVICES**



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The Federal Aviation Administration produced this report in cooperation with the U. S. Department of Agriculture, Wildlife Services, under an interagency agreement (DTFACT-14-X-00007). The purpose of this agreement is to 1) document wildlife strikes to civil aviation through management of the FAA National Wildlife Strike Database and 2) research, evaluate, and communicate the effectiveness of various habitat management and wildlife control techniques for minimizing wildlife strikes with aircraft at and away from airports. These activities provide a scientific basis for FAA policies, regulatory decisions, and recommendations regarding airport safety and wildlife.

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COVER PHOTOGRAPH

On November 19, 2017 at 1855 local time, a Bell 407 helicopter which had been en route at 1240 feet AGL and 116 knots, impacted terrain near Stuttgart, Arkansas. The pilot and two medical crewmembers were fatally injured, and the helicopter was destroyed. At the crash site, multiple bird remains were found from the cockpit area to the first bulkhead. Eleven bags of bird remains were sent to the Feather Identification Laboratory, Smithsonian Institution, National Museum of Natural History, Washington, D.C. The samples were compared with museum specimens; all were identified as snow geese. The size of the feathers (see below) was a key in determining that the birds were snow geese and not the similar but smaller Ross's geese which also migrate from the high arctic to wintering areas in the southern USA. Snow geese have mean body masses of 2.8 kg for males and 2.5 kg for females compared to about 1.6 kg for Ross's geese (both sexes). Photos, Smithsonian Feather Lab.



Dark primary wing feather from the wreckage (at arrow in foreground) compared with museum specimen (background) from snow goose. The large size of the entire feather and the feather shaft (rachis) matched the snow goose and excluded the closely related but smaller Ross's goose.

ACKNOWLEDGMENTS

The National Wildlife Strike Database (NWSD) office acknowledges and thanks the many people who took the time and effort to report the 197,833 wildlife strikes summarized in this report – pilots, mechanics, control tower and airport operations personnel, airline flight safety officers, airport wildlife biologists, and many others.

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Finally, the NWSD office acknowledges the suggestions and critiques made by various people over the years that have enhanced the usefulness and accuracy of the NWSD and annual reports such as presented here. We particularly acknowledge the advice provided by **Roger Nicholson**, Boeing Aircraft Company.

Sponsorship and funds for the ongoing maintenance and analysis of the NWSD are provided by the FAA, Office of Airport Safety and Standards, Washington, DC, and the Airport Technology Research and Development Branch, FAA William J. Hughes Technical Center, Atlantic City, NJ.

EXECUTIVE SUMMARY - WILDLIFE STRIKES TO CIVIL AIRCRAFT IN THE UNITED STATES, 1990–2017

Aircraft collisions with birds and other wildlife (wildlife strikes) continue to be a serious aviation safety issue as demonstrated by the emergency forced landing of an Airbus 320 with 155 passengers and crew in the Hudson River in 2009 after Canada geese were ingested in both engines. The incident resulted in increased media attention and demonstrated to the public that wildlife strikes are a serious but manageable aviation safety issue. The civil and military aviation communities continue to understand that the threat from aircraft collisions with wildlife is real and increasing. Globally, wildlife strikes have killed more than 287 people and destroyed over 263 aircraft from 1988 through November 2018. Factors that contribute to this increasing threat are increasing populations of large birds and increased air traffic by quieter, turbofan-powered aircraft.

This report presents a summary analysis of data from the National Wildlife Strike Database for the 28-year period 1990 through 2017. A sample of 20 significant wildlife strikes to civil aircraft in the USA during 2017 is also included as Appendix A.

The number of strikes annually reported to the FAA increased 7.8-fold from 1,850 in 1990 to a record 14,496 in 2017. The 2017 total was an increase of 1,069 strikes (7 percent) compared to the 13,427 strikes reported in 2016. For 1990–2017, 197,833 strikes were reported (193,969 in USA and 3,864 strikes by U.S.-registered aircraft in foreign countries). In 2017, birds were involved in 95.0 percent of the reported strikes, bats in 2.9 percent, terrestrial mammals in 1.8 percent and reptiles in 0.3 percent.

Although the number of reported strikes has dramatically increased, the number of reported damaging strikes has declined since 2000. Whereas the number of reported strikes increased 144 percent in USA airspace from 5,872 in 2000 to 14,349 in 2017, the number of damaging strikes declined 16 percent from 741 to 625. The decline in damaging strikes has been most pronounced for commercial aircraft in the airport environment (at $\leq 1,500$ feet above ground level [AGL]). Damaging strikes have not declined for general aviation (GA) aircraft.

In 2017, 70 percent and 1 percent of the 13,795 strike reports were filed using the electronic and paper versions, respectively, of FAA Form 5200-7, Bird/Other Wildlife Strike Report. Eleven percent of the reports were submitted via the Air Traffic Organization Mandatory Occurrence Reporting system and 18 percent came from multiple sources.

The number of USA airports with strikes reported increased from 335 in 1990 to a record 698 in 2017. The 698 airports with strikes reported in 2017 were comprised of 420 airports certificated for passenger service under 14 CFR Part 139 and 278 GA aviation airports. From 1990 - 2017, strikes have been reported from 2,009 USA airports.

Fifty-three percent of bird strikes occurred between July and October; 29 percent of deer strikes occurred in October - November. Terrestrial mammals are more likely to be struck

at night (63 percent) whereas birds are struck more often during the day (63 percent). Birds, terrestrial mammals, and bats are all much more likely to be struck during the arrival phase of flight (62, 65, and 85 percent of strikes, respectively) compared to departure (36, 33 and 14 percent, respectively).

For commercial and GA aircraft, 71 and 73 percent of bird strikes, respectively, occurred at or below 500 feet AGL. Above 500 feet AGL, the number of strikes declined by 34 percent for each 1,000-foot gain in height for commercial aircraft, and by 44 percent for GA aircraft. Strikes occurring above 500 feet were more likely to cause damage than strikes at or below 500 feet. The record height for a reported bird strike was 31,300 feet.

From 1990 to 2017, 550 species of birds, 44 species of terrestrial mammals, 26 species of bats, and 20 species of reptiles were identified as struck by aircraft. Waterfowl, gulls, and raptors are the species groups of birds with the most damaging strikes; Artiodactyls (mainly deer) and carnivores (mainly coyotes) are the terrestrial mammals with the most damaging strikes. Although the percentage of wildlife strikes with reported damage has averaged 8 percent for the 28-year period, this number has declined from 20 percent in 1990 to 4 percent in 2017.

A negative effect-on-flight was reported in 6 percent and 19 percent of the bird and terrestrial mammal strike reports, respectively, 1990-2017. Precautionary/emergency landing after striking wildlife was the most commonly reported negative effect (6,222 incidents), including 246 incidents in which the pilot jettisoned fuel (58 events, mean of 14,373 gallons), made an overweight landing (105 incidents), or burned fuel in circling pattern (83 incidents). Aborted take-off was the second most commonly reported negative effect (2,427 incidents). These negative incidents included 542 aborted take-offs at ≥ 100 knots. Similar to the trend shown for the percentage of strikes causing damage, the percentage of strikes with a reported negative effect-on-flight has declined from a high of 12 percent in 1996 to 4 percent in 2014-2017. For commercial aircraft, the number of high-speed (≥ 100 knots) aborted take-offs has declined from a high of 25 in 2000 to 6-9 in 2015-2017.

For the 30 species of birds most frequently identified as struck by civil aircraft in 2017, there was a strong correlation ($R^2 = 0.88$) between mean body mass and the likelihood of a strike causing damage to aircraft. For every 100 gram increase in body mass, there was a 1.16 percent increase in the likelihood of damage. Thus, body mass is a good predictor of relative hazard level among bird species.

Seventy strikes resulted in a destroyed aircraft from 1990-2017; 45 (64 percent) of these occurred at GA airports. The annual cost of wildlife strikes to the USA civil aviation industry in 2017 was projected to be a minimum of 71,253 hours of aircraft downtime and \$142 million in direct and other monetary losses. Actual losses are likely 2 or more times higher.

This analysis of 28 years of strike data documents the progress being made in reducing damaging strikes for commercial aircraft that primarily use Part 139-certificated airports. Management actions to mitigate the risk have been implemented at many airports since

the 1990s; these efforts are likely responsible for the general decline in reported strikes with damage and a negative effect-on-flight at Part 139-certificated airports from 2000-2017 in spite of continued increases in populations of many large bird species. However, much work remains to be done to reduce wildlife strikes. Management actions at airports should be prioritized based on the hazard level of species observed in the aircraft operating area.

To address strikes outside the airport environment, the general public and aviation community must first widen its view of wildlife management to minimize hazardous wildlife attractants within 5 miles of airports. Second, the aviation community needs to broaden the view of wildlife strike risks from a ground-based wildlife management problem to an airspace management problem that also encompasses Air Traffic Control, flight crews, and aircraft manufacturers. Long-term goals include the integration of avian radar and bird migration forecasting into airspace management and the development of aircraft lighting systems to enhance detection and avoidance by birds. Finally, there continues to be a need for increased and more detailed strike reporting. When reports are filed, it is important that relevant information be provided whenever possible regarding species identification, number of wildlife struck, time and height of strike, phase of flight, and damage to aircraft components. A problem that is not well defined cannot be properly managed.

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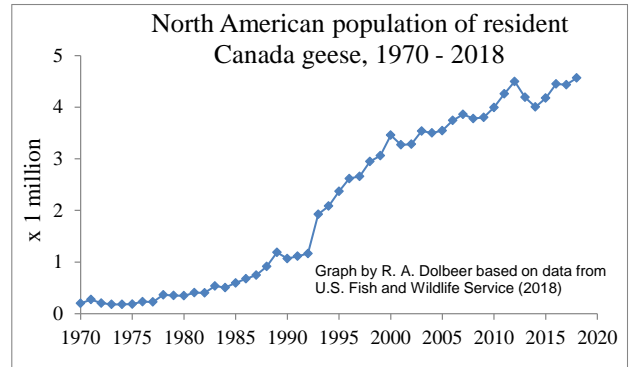
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WILDLIFE STRIKES TO CIVIL AIRCRAFT IN THE UNITED STATES, 1990–2017

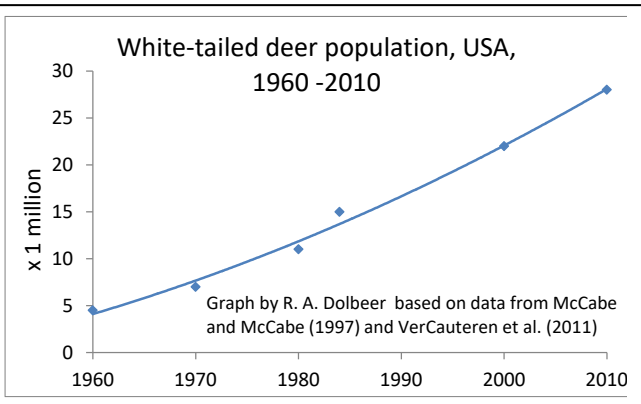
INTRODUCTION

Aircraft collisions with birds and other wildlife (wildlife strikes) continue to be a serious aviation safety issue as demonstrated by the emergency forced landing of an Airbus 320 with 155 passengers and crew in the Hudson River in 2009 after Canada geese were ingested in both engines (National Transportation Safety Board 2010, Marra et al. 2009) and the 19-fatality crash of a Dornier 228-200 in Nepal in 2012 after a black kite was struck on take-off (Thorpe 2012). In 2017, a Bell 407 helicopter crashed in Arkansas after striking a flock of snow geese at night, killing the 3 persons onboard (National Transportation Safety Board 2018). Globally, bird and other wildlife strikes killed more than 287 people and destroyed over 263 aircraft from 1988 – November 2018 (Richardson and West 2000; Thorpe 2012, Shaw and Dolbeer 2018). Three factors that contribute to this increasing threat are:

1. Many populations of large bird and mammal species commonly involved in strikes increased markedly in the last few decades and adapted to living in urban environments, including airports. For example, the resident (non-migratory) Canada goose population in the USA and Canada increased from about 1 million to over 4 million from 1990 to 2018 (Dolbeer et al. 2014, U.S. Fish and Wildlife Service. 2018). During the same time period, the North American snow goose population increased from about 4 million to 15 million birds (U.S. Fish and Wildlife Service. 2018). Dolbeer and Begier (2013) examined the estimated population trends and numbers for the 21 species of birds in North America with mean body masses ≥ 4 lbs and at least 10 strikes with civil aircraft from 1990-2012. Of these 21 species, 17 had shown population increases from 1990-2012 with a net gain of 17 million birds. Previous



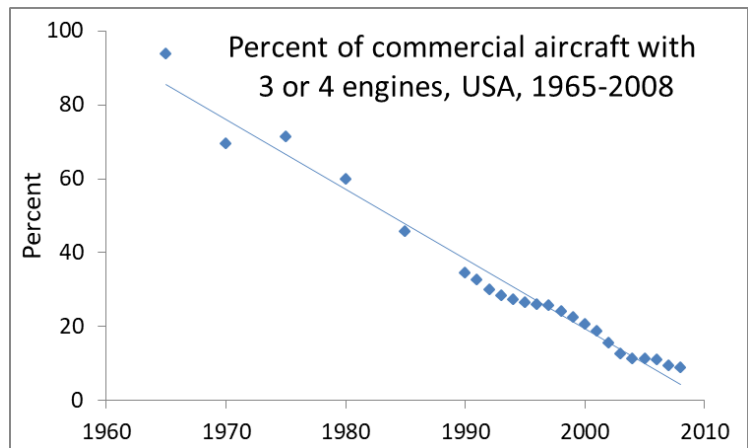
Resident (generally non-migratory) geese are primarily the Atlantic Flyway Resident, Mississippi Flyway Giant, Hi-Line, and Western Prairie/Great Plains Populations. In 2017, 72 strikes were reported for Canada geese, compared to peak numbers of 84-87 in 1998-2000.



research had documented that 13 of the 14 bird species in North America with mean body masses ≥ 8 lbs showed significant population increases from 1970 to the early 1990s (Dolbeer and Eschenfelder 2003). The white-tailed deer population increased from a low of about 350,000 in 1900 to about 15 million in 1984 and to over 28 million by 2010 (McCabe and McCabe 1997, VerCauteren et al. 2011).

2. Concurrent with population increases of many large bird species, commercial air traffic in the USA increased from about 23 million movements in 1990 to a peak of 28 - 29 million movements in 2000 – 2008 (Table 2). From 2008 to 2017, commercial air traffic declined to 25 million movements although passenger enplanements increased from about 750 million to 850 million (Federal Aviation Administration 2018a). Commercial air traffic in the USA is predicted to grow at a rate of about 1.1 percent per year from 25 million movements in 2017 to 30 million by 2030. Passenger enplanements are predicted to grow at a rate of about 2.3 percent per year from 850 million in 2017 to 1.14 billion in 2030.

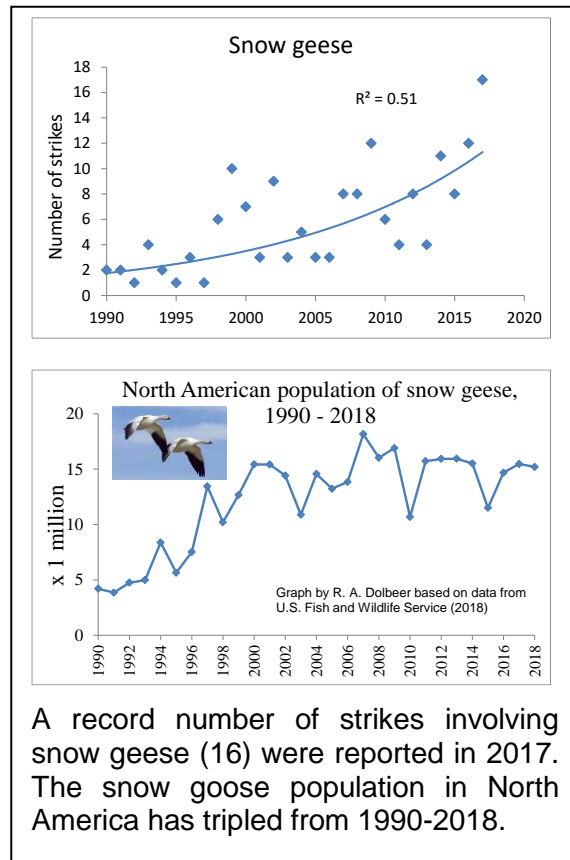
3. Commercial air carriers have replaced their older three or four-engine aircraft fleets with more efficient and quieter, two-engine aircraft. In 1965, about 87 percent of the 1,037 turbine-powered passenger aircraft in the USA had three or four engines. By 1990, the fleet had grown to 5,743 turbine-powered aircraft of which 32 percent had 3 or 4 engines. In 2008,



only 8 percent of the 7,371 turbine-powered aircraft had three or four engines (U.S. Department of Transportation 2018). With the steady advances in technology over the past several decades, today's two-engine aircraft are more powerful and reliable than yesterday's three and four-engine aircraft. However, in the event of a multiple ingestion event (e.g., the US Airways Flight 1549 incident on 15 January 2009), aircraft with two engines may have vulnerabilities not shared by their three or four engine-equipped counterparts. In addition, previous research has indicated that birds are less able to detect and avoid modern jet aircraft with quieter turbofan engines (Chapter 3, International Civil Aviation Organization 1993) than older aircraft with noisier (Chapter 2) engines (Burger 1983, Kelly et al. 1999).

As a result of these factors, experts within the Federal Aviation Administration (FAA), U.S. Department of Agriculture (USDA), U.S. Air Force, U.S. Navy, and U.S. Army expect the risk of wildlife-aircraft collisions to be a continuing challenge over the next decade.

The FAA has initiated several programs to address this important safety issue. Among the various programs is the collection and analysis of data from wildlife strikes. The FAA began collecting wildlife strike data in 1965. However, except for cursory examinations of strike reports to determine general trends, the data were never submitted to rigorous analysis until the 1990s. In 1995, the FAA, through an interagency agreement with the USDA, Wildlife Services (USDA/WS), initiated a project to obtain more objective estimates of the magnitude and nature of the national wildlife strike problem for civil aviation. Specialists from the USDA/WS: (1) edit all strike reports (FAA Form 5200-7, *Bird/Other Wildlife Strike Report*) received by the FAA since 1990 to ensure consistent, error-free data; (2) enter all edited strike reports into the FAA National Wildlife Strike Database; (3) supplement FAA-reported strikes with additional, non-duplicated strike reports from other sources;; and (4) assist the FAA with the production of annual and special reports summarizing the results of analyses of the data from the National Wildlife Strike Database. Such analyses are critical to determining the economic cost of wildlife strikes, the magnitude of safety issues, and most important, the nature of the problems (e.g., wildlife species involved, types of damage, height and phase of flight during which strikes occur, and seasonal patterns). The information obtained from these analyses provides the foundation for FAA national policies and guidance and for refinements in the development and implementation of integrated research and management efforts to reduce wildlife strikes. Data on the number of strikes causing damage to aircraft or other adverse effects (e.g., aborted take-off) also provide a benchmark for individual airports to evaluate and improve their Wildlife Hazard Management Plans in the context of a Safety Management System (Dolbeer and Begier 2012). Airport Wildlife Strike Summary and Risk Analysis Reports, which summarize strike data for the most current 5-year period, are available for most Part 139-certificated airports at



<http://wildlifecenter.pr.erau.edu/strikeInformation.html>.

The first annual report on wildlife strikes to civil aircraft in the USA was completed in November 1995 (Dolbeer et al. 1995). This is the 24th report in the series and covers the 28-year period, 1990–2017. Current and historic annual reports are accessible as PDF files at: http://www.faa.gov/airports/airport_safety/wildlife/

To supplement the statistical summary of data presented in tables and graphs, a sample of 20 significant wildlife strikes to civil aircraft in the USA during 2017 is presented in Appendix A. These recent strike examples demonstrate the widespread and diverse

nature of the problem. A more extensive list of significant strike events, 1990–2018, is available at http://www.faa.gov/airports/airport_safety/wildlife/.

RESULTS

NUMBER OF REPORTED STRIKES AND STRIKES WITH DAMAGE

The number of strikes annually reported to the FAA has increased 7.8-fold from 1,850 in 1990 to a record 14,496 in 2017. The 2017 total was an increase of 1,069 strikes (7 percent) compared to the 13,427 strikes reported in 2016 (Table 1, Figure 1). For the 28-year period (1990–2017), 197,833 strikes were reported of which 193,969 (98 percent) occurred in the USA¹. In 2017, birds were involved in 95.0 percent of the reported strikes in the USA, terrestrial mammals in 1.8 percent, bats in 2.9 percent and reptiles in 0.3 percent (Table 2).

Although the number of reported strikes has steadily increased in the USA airspace, it is important to note that the overall number of reported damaging strikes has actually declined since 2000 (Table 2, Figure 2). Whereas the number of reported strikes increased 144 percent from 5,872 in 2000 to 14,349 in 2017, the number of damaging strikes declined 16 percent from 741 to 625. However, the 625 damaging strikes reported in 2017 was an increase of 8 percent from 578 in 2016.

This overall decline in damaging strikes since 2000 has occurred in the commercial aviation sector and not the general aviation sector. While the number and rate (per 100,000 movements) of all strikes with commercial aircraft has increased 85 and 118 percent, respectively, from 2000 to 2017, the number and rate of damaging strikes has declined 23 and 9 percent, respectively (Table 3, Figure 3).

Furthermore, the decline in damaging strikes for commercial aircraft since 2000 has occurred in the airport environment (strikes occurring on departure or arrival at $\leq 1,500$ feet above ground level [AGL]). Damaging strikes at $>1,500$ feet AGL have not shown a pattern of decline (Figure 4). These declines in damaging strikes for commercial aviation have occurred in spite of an increase in populations of hazardous wildlife species (Dolbeer and Eschenfelder 2003, Dolbeer and Begier 2013) and, as noted above a major increase in reported strikes. These data demonstrate progress in wildlife hazard management programs at airports certificated for passenger traffic under 14 CFR-Part 139 regulations



Resident populations of Canada geese have adapted to living in close association with humans in urban environments such as parks and golf courses. Resident populations within 5 miles of airports should be managed to reduce numbers (Rutledge et al. 2015). Photo, R. A. Dolbeer.

¹ The database contains strikes involving U.S.- or foreign-registered aircraft in the USA and U.S.-registered aircraft in foreign countries.

(Dolbeer 2011). The data also demonstrate the lack of progress in mitigating the risk of strikes outside the airport environment at certificated airports.

As with commercial aircraft, there has been a steady increase in the strike rate for general aviation (GA) aircraft, from 0.77 in 2000 to 1.91-2.06 in 2014-2017 (Table 4). However, in contrast to commercial aviation, the rate of damaging strikes with GA aircraft has not



In July 2017, a B-737 on short final at Deadhorse, Alaska Airport struck a caribou at touchdown markers as pilot initiated a go-around. The aircraft then circled multiple times prior to safely landing. Inspection revealed the outer tire on right main gear struck the caribou. No damage to aircraft but fatal strike to Caribou. Photo, Deadhorse Airport.

declined since 2000 but has fluctuated between 0.23 (in 2001 and 2005) and 0.42 (in 2013, Table 4, Figure 3). For GA aircraft, there has not been a decline in damaging strikes in the airport environment (at $\leq 1,500$ feet AGL), and there has been an increase in damaging strikes at $>1,500$ feet AGL (Figure 4).

The 144 percent increase in the number of strikes reported from 2000 to 2017, concurrent with a decline in damaging strikes, indicates that airports, pilots, and commercial aviation in general, are doing a better job of documenting all wildlife that are struck, many of which are small species that rarely cause damage. This premise is supported by the fact that the mean mass of birds reported as struck has declined 60 percent from 0.76 kg to 0.30 kg, 2000-2017 (Figure 5).

METHODS OF REPORTING STRIKES

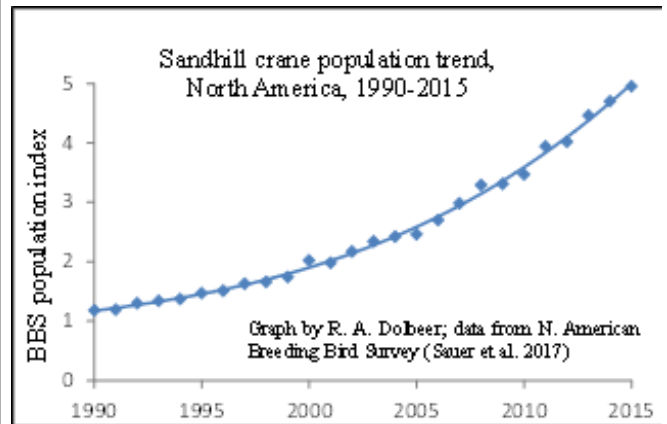
In 2017, 70 percent and 1 percent of the 14,497 strike reports were filed using the electronic and paper versions, respectively, of FAA Form 5200-7, *Bird/Other Wildlife Strike Report* (Table 5). Eighteen percent of reports came from multiple sources (i.e., more than one type of report was filed

for same strike). Strike reports submitted to the FAA via the Air Traffic Organization (ATO) Mandatory Occurrence Reporting system comprised 11 percent of reports. Under FAA Order JO 7210.632, (effective 30 Jan 2012), ATO personnel are required to report all bird strikes of which they become aware.

SOURCE OF REPORTS

In 2017, airport operations personnel filed 69 percent of the strike reports (including “Carcass Found” reports), followed by pilots (14 percent), air transport operations personnel (13 percent), Air Traffic Control personnel (3 percent), and other (2 percent, Table 6). In 2017, about 86 percent of the reported strikes involved commercial aircraft; the remainder involved business, private, and government aircraft (Table 7).

The number of USA airports with strikes reported has increased steadily from 335 in 1990 to a record 698 in 2017 (Table 8, Figure 6). The 698 airports with strikes reported in 2017 were comprised of 420 airports certificated for passenger service under 14 CFR Part 139 and 278 general aviation airports. From 1990 - 2017, 170,977 strikes have been reported from 2,009 USA airports. In addition, 3,864 strikes involving USA-registered civil aircraft were reported at 308 foreign airports in 109 countries, 1990 – 2017 (147 strikes at 82 foreign airports in 45 countries in 2017).

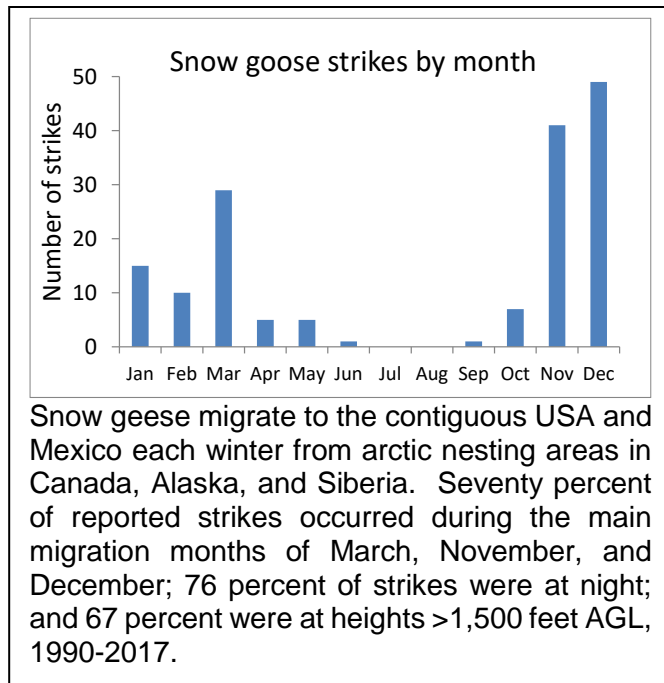


An Airbus 320 struck a migrating sandhill crane at 2000 feet over the Potomac River in Virginia during departure from Reagan National Airport, April 2017. The bird created a 12-inch dent in the right wing. The pilot made an emergency landing at Dulles International Airport. Remains were identified by Smithsonian Feather Lab. The sandhill crane population in North America has increased about 5-fold since 1990. Photo, USDA.

TIMING OF OCCURRENCE AND PHASE OF FLIGHT OF STRIKES

From 1990 – 2017, most bird strikes (53 percent) occurred between July and October (Figure 7) which is when birds are migrating and populations are at their annual peak in North America following the nesting season. Sixty-three percent of bird strikes occurred during the day and 29 percent at night (Table 9). Almost twice as many strikes (62 percent of total) occurred during the arrival (descent, approach, or landing roll) phase of flight compared to 36 percent during departure (take-off run and climb, Table 10).

Similar to the pattern shown with birds, most terrestrial mammal strikes occurred between July and November; with 29 percent of deer strikes concentrated in October-November and 40 percent of coyote strikes in August-October (Figure 8). Most terrestrial mammal strikes (63 percent) occurred at night (Table 9). As with birds, about twice as many strikes (65 percent of total) occurred during the arrival (final approach or landing roll) phase of flight compared to 33 percent during take-off run and initial climb (Table 10).



For bats, 75 percent of strikes occurred at dusk, dawn or night (Table 9). The difference in numbers of strikes during arrival compared to departure phase of flight was even greater for bats compared to birds and terrestrial mammals. Eighty-five percent of reported bat strikes occurred during arrival compared to only 14 percent during departure (Table 10).

HEIGHT ABOVE GROUND LEVEL (AGL) OF STRIKES

Bird strikes with commercial aircraft-

From 1990 – 2017, about 41 percent of bird strikes with commercial aircraft occurred when the aircraft was at 0 feet AGL, 71 percent occurred at 500 feet or

less AGL, and 92 percent occurred at or below 3,500 feet AGL (Table 11). About 1 percent of bird strikes occurred above 9,500 feet AGL. Above 500 feet AGL, the number of reported strikes declined consistently by 34 percent for each 1,000-foot gain in height (Figure 9). The record height for a reported bird strike involving a commercial aircraft in USA was 31,300 feet AGL.

Strikes occurring above 500 feet AGL had a greater probability of causing damage to the aircraft compared to strikes at 500 feet or less. Although only 29 percent of the reported strikes were above 500 feet AGL, these strikes represented 45 percent of the damaging strikes (Table 11, Figure 10).

Bird strikes with general aviation (GA) aircraft-

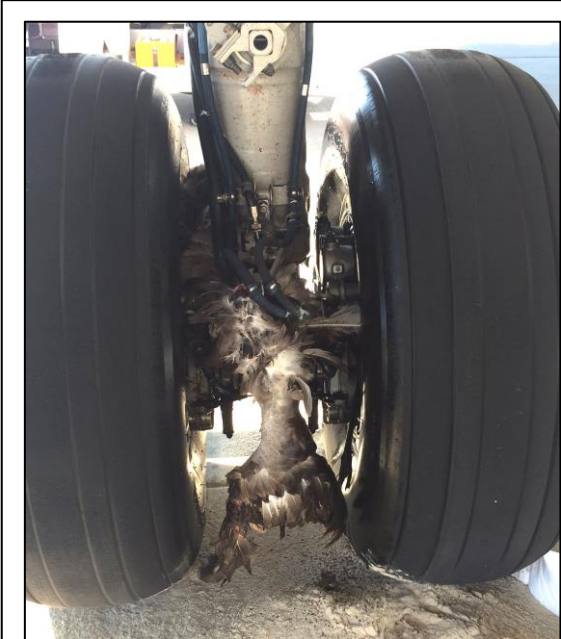
From 1990 – 2017, about 37 percent of the bird strikes with GA aircraft occurred when the aircraft was at 0 feet AGL, 73 percent occurred at 500 feet or less AGL, and 96 percent occurred at or below 3,500 feet AGL (Table 12). About 1 percent of bird strikes occurred above 8,500 feet AGL. Above 500 feet AGL, the number of reported strikes declined consistently by 44 percent for each 1,000-foot gain in height (Figure 9). The record height for a reported bird strike involving a GA aircraft in USA was 24,000 feet AGL.

Strikes occurring above 500 feet AGL had an even greater probability of causing damage to GA aircraft compared to strikes at 500 feet or less than was shown above for commercial aircraft. Although only 27 percent of the reported strikes were above 500 feet AGL, these strikes represented 50 percent of the damaging strikes (Table 12, Figure 10).

Terrestrial mammal strikes- As expected, terrestrial mammal strikes predominately occurred at 0 feet AGL; however, 9 percent of the reported strikes occurred when the

aircraft was in the air immediately after lift-off or before touch down (e.g., when an aircraft struck a deer with the landing gear, Table 10).

AIRCRAFT COMPONENTS DAMAGED



An MD-83 struck a sandhill crane during take-off run at a central Florida airport in May 2017. The aircraft continued to destination airport with crane embedded in landing gear. Upon landing, the bird was discovered along with a severed hydraulic line and fluid leakage. The crane had been banded and equipped with a GPS tracker 6 months earlier (Nov 2016) in Wisconsin. Photo, airport.

The aircraft components most commonly reported as struck by birds from 1990 – 2017 were the nose/radome, windshield, wing/rotor, engine, and fuselage (Table 13). Aircraft engines were the component most frequently reported as being damaged by bird strikes (27 percent of all damaged components). There were 18,527 strike events in which a total of 19,401 engines were reported as struck (17,682 events with one engine struck, 823 with two engines struck, 15 with three engines struck, and 6 with four engines struck). In 4,634 damaging bird-strike events involving engines, a total of 4,787 engines was damaged (4,484 events with one engine damaged, 148 with two engines damaged, 1 with three engines damaged, and 1 with four engines damaged).

Aircraft components most commonly reported as struck by terrestrial mammals were the landing gear, “other”, propeller, and wing/rotor. Aircraft components most commonly reported as damaged were the landing gear, wing/rotor, propeller, and “other” (Table 13).

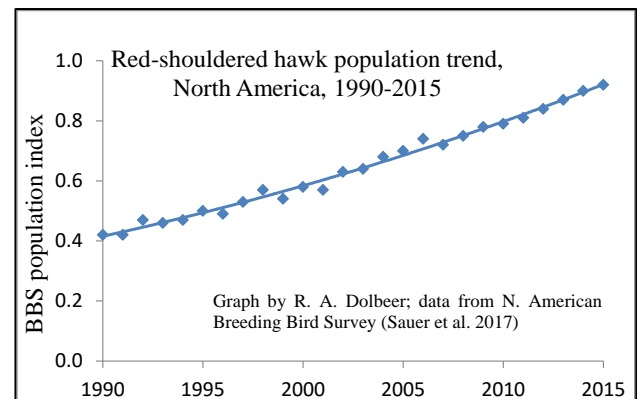
REPORTED DAMAGE

For the 191,172 strike reports involving birds from 1990–2017, 14,744 (8 percent) indicated damage to the aircraft (Table 14). When classified by level of damage, 7,527 (4 percent) indicated the aircraft suffered minor damage; 3,622 (2 percent) indicated the aircraft suffered an uncertain level of damage; 3,566 (2 percent) reported substantial damage; and 39 reports (less than 1 percent) indicated the aircraft was destroyed as a result of the bird strike (Table 14).

For the 4,066 terrestrial mammal strikes reported, 1,116 (27 percent) indicated damage to the aircraft. When classified by level of damage; 559 (14 percent) indicated the aircraft suffered minor damage; 422 (10 percent) indicated the aircraft suffered substantial damage; 104 (3 percent) reported an uncertain level of damage; and 31 (1 percent)



An Embraer 175 departing a Pennsylvania airport in May 2017 ingested a red-shouldered hawk into the #1 engine at 400 feet AGL, 1 mile from runway. The pilot reported damage to the engine and returned safely to the airport. The red-shouldered hawk population in North America has more than doubled since 1990 to over 1.6 million birds (Rosenberg et al. 2016). Photo, airport.



indicated the aircraft was destroyed as a result of the strike (Table 14). Not surprisingly, a much higher percentage of terrestrial mammal strikes (27 percent) resulted in aircraft damage than did bird strikes (8 percent). Deer (1,158 strikes, of which 966 caused damage; Table 18) were involved in 28 percent of the strikes and 87 percent of the damaging strikes involving terrestrial mammals.

Although the percentage of wildlife strikes (all species) with reported damage has averaged 8 percent for the 28-year period (Table 14), this number has declined from 20 percent in 1990 to 4 percent in 2017 (Figure 11).

REPORTED NEGATIVE EFFECT-ON-FLIGHT

A negative effect-on-flight was reported in 6 percent and 19 percent of the bird and terrestrial mammal strike reports, respectively, (Table 15). Precautionary/emergency landing after striking wildlife was the most commonly reported negative effect (6,222 incidents, 3 percent of strike reports). These precautionary landings included 246 incidents in which the pilot jettisoned fuel (58) or burned fuel in a circling pattern (83) to lighten aircraft weight or

in which an overweight landing was made (105, Table 16, Figure 12). In the 58 reported incidents in which fuel was jettisoned, an average of 94,358 pounds (13,876 gallons) of fuel was dumped per incident (range 44 – 39,706 gallons).

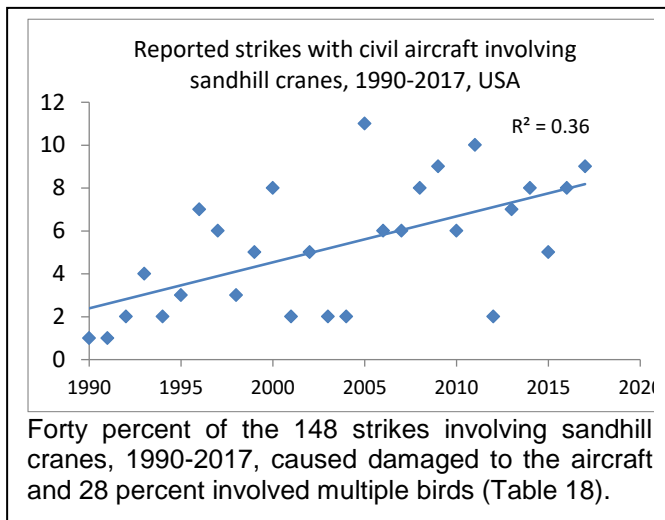
Aborted take-off after striking wildlife was the second most commonly reported negative effect (2,427 incidents, 1 percent of strike reports, Table 15). These negative incidents included 542 aborted take-offs in which the pilot initiated the abort at an aircraft speed of 100 knots (115 miles per hour) or greater (Table 17). For commercial aircraft, the number of high-speed aborted take-offs has declined from a high of 25 in 2000 to a low of 6-9 in

2015-2017 (Figure 13). For general aviation aircraft, the number of high-speed aborted take-offs has averaged about 4 per year although there were none reported in 2017.

Similar to the trend shown for the percent of strikes causing damage, the percentage of wildlife strikes (all species) with a reported negative effect-on-flight has declined from a high of 12 percent in 1996 to 4 percent in 2014-2017 (Figure 11).

WILDLIFE SPECIES INVOLVED IN STRIKES

Table 18 shows the number of reported strikes, strikes causing damage, strikes having a negative effect-on-flight, strikes involving >1 animal, the reported aircraft down time, and the reported costs by identified wildlife species, 1990 - 2017. This information can be useful in comparing the relative hazard level of bird and other wildlife species encountered during Wildlife Hazard Assessments at airports and in the development of priorities for Wildlife Hazard Management Plans (see also Dolbeer and Wright 2009 and DeVault et al, 2011).



Birds- Of the 191,172 reported bird strikes, 82,935 (43 percent) identified the bird to exact species and an additional 21,077 strikes (11 percent) identified the bird at least to species group (e.g., gull, hawk, duck). Species identification has improved from less than 20 percent in the early 1990s to 61 percent in 2017 (Figure 14). In all, 550 species of birds have been identified as struck by aircraft, and 279 of these species were reported as causing damage, 1990–2017. In 2017, 340 bird species were identified as struck by civil aircraft (Figure 14).

Doves/pigeons (14 percent), raptors (13 percent), gulls (11 percent), shorebirds (9 percent), and waterfowl (5 percent) were the most frequently struck bird groups (Table 19). Doves/pigeons, raptors, and gulls each were involved in over 2 times more strikes than waterfowl (11,472-14,253 and 5,523, respectively). Waterfowl, however, were involved in 4.1 times more damaging strikes than doves/pigeons and 1.3 to 1.5 times more damaging strikes than gulls or raptors. Waterfowl comprised 28 percent of all damaging strikes in which the bird type was identified, 1990–2017. Doves/pigeons and gulls were responsible for the greatest number of bird strikes (2,565 and 2,286, respectively) that involved multiple birds.

Table 20 lists the 30 species of birds identified most frequently as struck by civil aircraft for 1990–2017 and for 2017 only. Mourning doves, American kestrels, killdeer, barn swallows, European starlings, and horned larks were the 6 most frequently identified species struck by civil aircraft overall from 1990–2017 and in 2017 only. Canada geese, the 12th most frequently identified species struck overall from 1990–2017, declined to the



An American coot penetrated the windshield of an EC-135 medical transport helicopter in April 2017, striking the pilot in the shoulder. The aircraft was en route in Iowa at night at 1500 feet AGL. The pilot, who received minor bruises and cuts from the bird and shattered windshield, landed the helicopter safely. About 85% of coot strikes occur at night during migration. Photo, aircraft owner.

20nd most frequently struck species in 2017 in spite of the fact that the overall population in North America has increased over 2 fold, 1990–2017 (U.S. Fish and Wildlife Service 2018). This decline is likely related to the integrated management programs implemented in the past decade at many airports to dissuade feeding and nesting by Canada geese (Dolbeer et al. 2014).

For the 30 species of birds most frequently identified as struck by civil aircraft in 2017, there was a strong correlation ($R^2 = 0.88$) between mean body mass and the likelihood of a strike causing damage to aircraft (Figure 15). For every 100 gram increase in body mass, there was a 1.16 percent increase in the likelihood of damage. Thus, body mass is a good predictor of relative hazard level among bird species, as noted previously by Dolbeer et al. (2000) and DeVault et al (2011).

Terrestrial mammals, bats, and reptiles- The most frequently struck terrestrial mammals were Carnivores and Artiodactyls (39 and 30 percent, respectively, Tables 18, 19). Coyotes were the most frequently struck Carnivore and deer were the most frequently struck Artiodactyl. Artiodactyls were responsible for 91 percent of the mammal strikes that resulted in damage and 71 percent of the mammal strikes that involved multiple animals. In all, 44, 26 and 20 identified species of terrestrial mammals, bats, and reptiles, respectively, were reported struck; 24, 4 and 2 identified species of these respective wildlife taxa caused damage to aircraft (Table 18).

HUMAN FATALITIES AND INJURIES DUE TO WILDLIFE STRIKES

For the 28-year period, reports were received of 14 wildlife strikes that resulted in 33 human fatalities (Table 20). Six of these strikes resulting in 8 fatalities involved unidentified species of birds. Red-tailed hawks (8 fatalities), American white pelicans (5), bald eagles (4), snow geese (3), Canada geese (2), and white-tailed deer, brown-pelicans, and turkey vultures (1 each) were responsible for the other 25 fatalities. Reports were received of 239 strikes that resulted in 313 human injuries (Table 21). Waterfowl (ducks and geese; 57 strikes, 65 humans injured), vultures (35 strikes, 44 injuries), and deer (21 strikes, 30 injuries) caused 113 (59 percent) of the 193 strikes resulting in injuries in which

the species or species group was identified. Vultures caused 44 (17 percent) of the 252 injuries in which the species or species group was identified.

AIRCRAFT DESTROYED DUE TO WILDLIFE STRIKES

For the 28-year period, reports were received of 70 aircraft destroyed or damaged beyond repair due to wildlife strikes (range of 0 to 6 per year, Tables 14, 22, Figure 16). The majority (45; 64 percent) were small ($\leq 2,250$ kg maximum take-off mass) general aviation (GA) aircraft. Terrestrial mammals (primarily white-tailed deer) were responsible for 31 (44 percent) of the incidents. Geese (6 incidents) and vultures (4 incidents) were



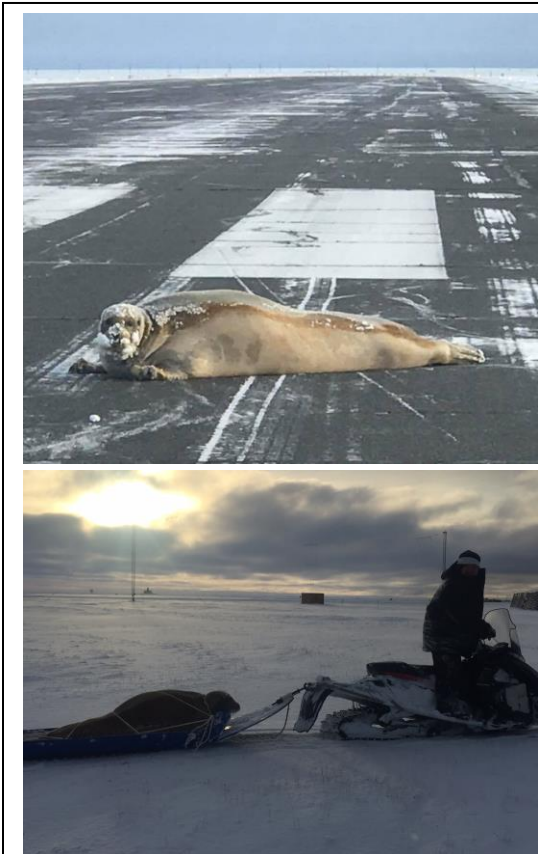
An EC-135 medical transport helicopter struck a duck at 1200 feet AGL while en route at night in Iowa, March 2017. The duck damaged the chin window and embedded in the fuselage at the air scoop. The pilot made a precautionary landing. The duck was not identified to species. Photo, aircraft operator.

responsible for 42 percent of the 24 incidents involving birds in which the species or species group was identified.

Forty-one (59 percent) of the 70 wildlife strikes resulting in a destroyed aircraft occurred at GA airports, 17 occurred en route, 7 occurred at USA airports certificated for passenger service under 14 CFR Part 139, and 3 occurred in miscellaneous situations (taking off from river, herding cattle, and aerial application of pesticides). Two occurred at a foreign airport (Table 22). GA airports, often located in rural areas with inadequate fencing to exclude large mammals, face unique challenges in mitigating wildlife risks to aviation (DeVault et al. 2008; Dolbeer et al. 2008).

ECONOMIC LOSSES DUE TO WILDLIFE STRIKES

Of the 27,258 reports from 1990 – 2017 that indicated the strike had an adverse effect on the aircraft and/or flight, 10,126 provided an estimate of the aircraft downtime (1,032,613 hours, mean = 102.0 hours/incident, Tables 18, 23, 24). Regarding monetary losses, 4,330 reports provided an estimate of direct aircraft repair costs (\$677.4 million, mean = \$156,449/incident), and 3,411 reports gave an estimate of other monetary losses (\$87.8 million, mean = \$25,730/incident)². Other monetary losses include such expenses as lost revenue, the cost of putting passengers in hotels, re-scheduling aircraft, and flight cancellations.



An Alaskan Airlines aircraft had to delay departure at Post/Rogers Memorial Airport, Utqiagvik (Barrow) Alaska after ground personnel observed a 450-lb bearded seal on the runway, October 2017. The seal was loaded on a sled and pulled to safety. Photo, Airport.

Analysis of 14 groups of strike reports from 3 Part 139 airports certificated for passenger service and 3 airlines for the years 1991-2004 indicated that 11 to 21 percent of all strikes were reported to the FAA (Cleary et al. 2005, Wright and Dolbeer 2005). An independent analysis of strike data for a certificated airport in Hawaii in the 1990s indicated a similar reporting rate (Linnell et al. 1999). Strike reporting for general aviation (GA) aircraft at GA airports was estimated at less than 5 percent in the 1990s and early 2000s (Dolbeer et al. 2008, Dolbeer 2009). More recent analyses estimated that strike reporting for all civil aircraft combined (commercial and general aviation) at Part 139 airports had improved to 39 percent in 2004-2008 and to 47 percent in 2009-2013 (Dolbeer 2009, 2015). Strike reporting for commercial aircraft only at Part 139 airports was an estimated 79 percent in 2004-2008 and 91 percent in 2009-2013; reporting of strikes with damage was estimated at 78 percent and 93 percent for these respective time periods. In addition to the underreporting of strikes, only 37 percent of the 27,258 reports from 1990–2017 indicating an adverse effect provided estimates of aircraft downtime, 16 percent provided estimates of repair (direct) costs, and 13 percent provided estimates of other (indirect) costs (these

respective percentages were 44, 15, and 17 for 2017 only, Tables 23, 24). Furthermore, some reports providing cost estimates were filed before aircraft damage and downtime had been fully assessed. As a result, the information on the number of strikes and

² Costs from years prior to 2017 are inflation-adjusted to 2017 U.S. dollars.

associated costs compiled (summarized by species of wildlife struck in Table 18) is believed to significantly underestimate the economic magnitude of the problem.

Assuming (1) all 27,258 reported wildlife strikes that had an adverse effect on the aircraft and/or flight engendered similar amounts of downtime and/or monetary losses and (2) that these reports are all of the damaging strikes that occurred, then at a minimum, wildlife strikes annually cost the USA civil aviation industry, on average, 111,284 hours of aircraft downtime and \$186 million in monetary losses (\$152 million in direct costs and \$34 million in other costs), 1990–2017 (Table 24). For 2017 only, the minimum estimates would be 71,253 hours of downtime and \$142 million in direct and indirect costs. For reasons outlined above, we project that actual costs are likely 2 or more times higher than these minimum estimates.

CONCLUSIONS

The analysis of 28 years of strike data reveals the magnitude and nature of wildlife strikes with civil aircraft in the USA, and documents that progress is being made in reducing damaging strikes. Although wildlife strikes continue to pose an economic and safety risk for civil aviation in the USA, management actions to mitigate these risks have been implemented at many airports, especially beginning in 2000 when the FAA's manual



A SIAI-Marchetti S.211 on a 3-mile approach to a Florida airport hit a turkey vulture at 3000 feet AGL in February 2017. The pilot landed the damaged aircraft safely. From 1990-2017, 755 turkey vultures, 181 black vultures, and 334 vultures unidentified to species were reported as struck by civil aircraft in USA (67, 13, and 2 in 2017). The combined turkey vulture and black vulture population in North America exceeds 9 million (Rosenberg et al. 2016). Photo, pilot.

Wildlife Hazard Management at Airports was initially available to airports nationwide (Cleary and Dolbeer 1999, second edition 2005). These efforts (examples of which are documented in Wenning et al. 2004, DeFusco et al. 2005, Dolbeer 2006a, Human Wildlife Conflicts Journal 2009, Human-Wildlife Interactions Journal 2011, Dolbeer 2011, DeVault et al. 2013, Dolbeer et al. 2014, Rutledge et al. 2015) are likely responsible for the general decline in reported strikes with damage and negative effects-on-flight from 2000-2017 for commercial aircraft (Table 1, Figures 2, 3, 4, 9, 11) in the airport environment (<1500 feet AGL) in spite of continued increases in populations of many large bird species. As another measure of the increase in wildlife management activities, USDA Wildlife Services biologists provided assistance at 890 civil and military airports nationwide in 2017 to mitigate wildlife risks to aviation

compared to only 42 airports in 1991 and 193 in 1998 (Begier et al. 2018). However, much work remains to be done to reduce wildlife strikes.

To address the problem in the airport environment, airport managers first need to assess the wildlife hazards on their airports with the help of qualified airport biologists (FAA Advisory Circular 150/5200-36B, Qualifications for Wildlife Biologist Conducting Wildlife Hazard Assessments and Training Curriculums for Airport Personnel Involved in Controlling Wildlife Hazards on Airports). They then must take appropriate actions, under



By examining digestive systems of birds struck at airports, biologists often can determine food sources that serve as attractants and need to be eliminated. The crops of these rock pigeons contained seeds from the Caley pea (*Lathyrus hirsutus*), an introduced wild pea native to Eurasia. Photo, DFW International Airport.

the guidance of these biologists, to minimize risks posed by wildlife. Management actions should be prioritized based on the hazard level of species (Table 18, Figure 14) observed in the aircraft operating area. The manual *Wildlife Hazard Management at Airports* (Cleary and Dolbeer 2005), available online in English, Spanish, and French at <http://wildlife.faa.gov>, provides guidance for conducting wildlife hazard assessments and in developing and implementing wildlife hazard management plans.

Management efforts to reduce the risks of bird strikes have primarily focused on airports since various historical analyses of bird strike data for civil aviation have indicated the majority of strikes occur in this environment (during take-off and landing at $\leq 1,500$ feet AGL (see Tables 11, 12; Figure 8). However, the successful mitigation efforts at Part

139-certificated airports that have reduced damaging strikes for commercial aviation in recent years have done little to reduce strikes outside the airport environment such as occurred with US Airways Flight 1549 in 2009 (Dolbeer 2011).

To mitigate the risk for strikes beyond the airport fence, the general public and aviation community must first widen its view of wildlife management to consider habitats and land uses within 5 miles (or sometimes greater distances) of airports (Pfeiffer et al. 2018). For example, wetlands, dredge-spoil containment areas, municipal solid waste landfills, and wildlife refuges typically attract hazardous wildlife. Such land uses, as discussed in FAA Advisory Circular 150/5200-33B, *Hazardous Wildlife Attractants on or Near Airports*, are often incompatible with aviation safety and should either be prohibited near airports or designed and operated in a manner that minimize the attraction of hazardous wildlife (e.g., Washburn et al. 2010).

Second, the aviation community needs to broaden the view of wildlife strike risks from a ground-based wildlife management problem solely dealt with by airports to an airspace management problem that also encompasses Air Traffic Control, flight crews, and aircraft manufacturers. Long-term goals include the integration of avian radar and bird migration forecasting into airspace management for civil aviation (Nohara et al. 2011, Gerringer et al. 2016). The development of aircraft lighting systems to enhance detection and avoidance by birds (Blackwell et al. 2012, DeVault et al. 2015, Dolbeer and Barnes 2017) is also needed as part of an integrated program.

Finally, there continues to be a need for increased and more detailed strike reporting, especially for general aviation aircraft. When reports are filed, relevant information should be provided whenever possible regarding species identification, number of wildlife struck, time and height of strike, phase of flight, and damage to aircraft components (Dolbeer 2015, see Appendix B: Reporting a Strike and Identifying Species of Wildlife Struck). A problem that is not well defined cannot be properly managed.

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TABLES

Table 1. Number of reported wildlife strikes to civil aircraft in USA and to U.S.-registered civil aircraft in foreign countries, 1990–2017.

Year	USA ¹		Foreign		Total	
	Strikes	Damage strikes	Strikes	Damage strikes	Strikes	Damage strikes
1990	1,816	366	34	6	1,850	372
1991	2,352	395	37	5	2,389	400
1992	2,529	360	38	5	2,567	365
1993	2,541	395	34	4	2,575	399
1994	2,600	453	35	7	2,635	460
1995	2,717	486	52	11	2,769	497
1996	2,885	492	51	10	2,936	502
1997	3,386	569	69	9	3,455	578
1998	3,733	574	67	10	3,800	584
1999	5,017	685	95	18	5,112	703
2000	5,872	741	128	21	6,000	762
2001	5,696	630	124	15	5,820	645
2002	6,084	661	142	11	6,226	672
2003	5,864	612	137	20	6,001	632
2004	6,402	610	159	16	6,561	626
2005	7,046	585	181	20	7,227	605
2006	7,079	579	162	18	7,241	597
2007	7,603	553	142	16	7,745	569
2008	7,445	511	187	14	7,632	525
2009	9,258	585	251	20	9,509	605
2010	9,677	579	229	18	9,906	597
2011	9,856	519	262	23	10,118	542
2012	10,651	591	266	21	10,917	612
2013	11,221	596	196	13	11,417	609
2014	13,466	569	228	15	13,694	584
2015	13,564	607	244	12	13,808	619
2016	13,260	578	167	11	13,427	589
2017	14,349	625	147	8	14,496	633
Total	193,969	15,506	3,864	377	197,833	15,883

¹ See Table 2 for breakdown of strikes occurring in USA by type of wildlife.

Table 2. Number of reported wildlife strikes to civil aircraft in USA by wildlife group, 1990–2017.

Year	Birds	Bats	Terrestrial mammals ¹	Reptiles ¹	Total strikes	Strikes with damage
1990	1,758	3	55	0	1,816	366
1991	2,291	3	58	0	2,352	395
1992	2,453	2	73	1	2,529	360
1993	2,469	6	66	0	2,541	395
1994	2,515	2	82	1	2,600	453
1995	2,620	4	85	8	2,717	486
1996	2,792	1	89	3	2,885	492
1997	3,277	1	94	14	3,386	569
1998	3,612	3	111	7	3,733	574
1999	4,915	6	95	1	5,017	685
2000	5,731	15	123	3	5,872	741
2001	5,543	8	137	8	5,696	630
2002	5,931	19	119	15	6,084	661
2003	5,716	20	123	5	5,864	612
2004	6,243	27	126	6	6,402	610
2005	6,881	27	131	7	7,046	585
2006	6,884	46	139	10	7,079	579
2007	7,375	52	169	7	7,603	553
2008	7,214	44	182	5	7,445	511
2009	8,952	67	229	10	9,258	585
2010	9,308	112	246	11	9,677	579
2011	9,505	138	198	15	9,856	519
2012	10,267	161	204	19	10,651	591
2013	10,760	224	204	33	11,221	596
2014	12,955	254	222	35	13,466	569
2015	13,000	317	211	36	13,564	607
2016	12,751	248	225	36	13,260	578
2017	13,625	409	258	57	14,349	625
Total	187,343	2,219	4,054	353	193,969	15,506

¹ For terrestrial mammals and reptiles, species with body masses <1 kilogram (2.2 pounds) are excluded from database (Dolbeer et al. 2005).

Table 3. Number and rate of reported wildlife strikes and strikes with damage for commercial air carrier aircraft, USA, 1990–2017 (see Figure 3).

Year	No. of reported strikes ¹		Aircraft movements (x 1 million) ²	Strikes/100,000 movements	
	All strikes	Strikes with damage		All strikes	Strikes with damage
1990	1,347	219	23.23	5.80	0.94
1991	1,779	249	24.75	7.19	1.01
1992	1,797	207	25.14	7.15	0.82
1993	1,781	232	25.54	6.97	0.91
1994	1,893	279	26.55	7.13	1.05
1995	1,983	311	27.01	7.34	1.15
1996	2,057	310	27.55	7.47	1.13
1997	2,431	368	27.73	8.77	1.33
1998	2,484	361	27.97	8.88	1.29
1999	3,782	461	28.73	13.16	1.60
2000	4,379	492	29.51	14.84	1.67
2001	4,050	430	29.13	13.90	1.48
2002	4,276	452	27.60	15.49	1.64
2003	4,153	398	27.88	14.90	1.43
2004	4,551	390	28.85	15.77	1.35
2005	4,982	398	29.22	17.05	1.36
2006	4,759	385	28.28	16.83	1.36
2007	4,861	338	28.44	17.09	1.19
2008	4,445	323	27.94	15.91	1.16
2009	5,884	371	25.45	23.12	1.46
2010	5,795	360	25.10	23.08	1.43
2011	5,729	321	25.11	22.81	1.28
2012	6,153	368	24.89	24.72	1.48
2013	6,283	308	24.59	25.55	1.25
2014	7,971	326	24.42	32.65	1.34
2015	7,854	333	24.57	31.96	1.36
2016	7,687	351	24.83	30.96	1.41
2017	8,116	381	25.06	32.38	1.52
Total	123,262	9,722	745.10	16.54	1.30

¹ Strikes involving an unknown operator (49,573 of which 48,305 were “Carcass Found” reports—see Tables 6 and 7) were excluded from this analysis as were all strikes by USA-registered aircraft in foreign countries.

² Departures and arrivals by fiscal year (1 Oct–30 Sep) for air carrier, commuter, and air taxi service aircraft (Federal Aviation Administration 2018a).

Table 4. Number and rate of reported wildlife strikes and strikes with damage for general aviation aircraft, USA, 1990–2017 (see Figure 3).

Year	No. of reported strikes ¹		Aircraft movements (x 1 million) ²	Strikes/100,000 movements	
	All strikes	Strikes with damage		All strikes	Strikes with damage
1990	334	134	77.45	0.43	0.17
1991	406	131	83.44	0.49	0.16
1992	432	142	82.23	0.53	0.17
1993	447	159	80.31	0.56	0.20
1994	475	172	79.11	0.60	0.22
1995	481	171	77.13	0.62	0.22
1996	505	179	78.88	0.64	0.23
1997	505	189	79.86	0.63	0.24
1998	566	204	84.16	0.67	0.24
1999	620	212	85.26	0.73	0.25
2000	673	246	87.00	0.77	0.28
2001	695	194	85.82	0.81	0.23
2002	783	209	85.72	0.91	0.24
2003	683	208	83.39	0.82	0.25
2004	695	217	82.63	0.84	0.26
2005	667	186	81.09	0.82	0.23
2006	687	194	80.11	0.86	0.24
2007	670	212	80.15	0.84	0.26
2008	627	186	77.96	0.80	0.24
2009	861	214	73.54	1.17	0.29
2010	845	216	71.17	1.19	0.30
2011	918	198	69.85	1.31	0.28
2012	1,029	223	69.52	1.48	0.32
2013	1,107	287	68.77	1.61	0.42
2014	1,339	241	68.15	1.96	0.35
2015	1,406	273	68.28	2.06	0.40
2016	1,377	224	67.87	2.03	0.33
2017	1,303	230	68.07	1.91	0.34
Total	21,136	5,651	2176.91	0.97	0.26

¹ Strikes involving an unknown operator (49,573 of which 48,305 were “Carcass Found” reports—see Tables 6 and 7) were excluded from this analysis as were all strikes by USA-registered aircraft in foreign countries.

² Itinerant and local departures and arrivals by fiscal year (1 Oct–30 Sep) for general aviation aircraft (Federal Aviation Administration 2018a).

Table 5. Methods of reporting and source of information for reported wildlife strikes to civil aircraft, USA¹, 2017 only and 1990–2017.

Source	2017 only		1990-2017	
	Total	% of total	Total	% of total
FAA Form 5200-7E (Electronic) ²	10,196	70	103,010	52
Multiple ³	2,581	18	19,058	10
Mandatory Occurrence Report (MOR)	1,567	11	4,644	2
FAA Form 5200-7 (Paper) ²	136	1	43,111	22
Air Transport Report	12	<1	15,520	8
Airport Report	3	<1	6,255	3
Other ⁴	2	<1	1,868	1
Daily Report (FAA)	0	0	1,575	1
Preliminary Aircraft Incident Report	0	0	880	<1
Engine Manufacturer	0	0	812	<1
Aircraft Incident Report	0	0	712	<1
Aviation Safety Reporting System	0	0	198	<1
National Transportation Safety Board	0	0	83	<1
Aircraft Incident Preliminary Notice	0	0	67	<1
Transport Canada	0	0	37	<1
U.S. Air Force (BASH)	0	0	4	<1
Total	14,497	100	197,834	100

¹ Includes strikes to U.S.-registered aircraft in foreign countries.

² Bird/Other Wildlife Strike Report. Electronic filing of reports (<http://wildlife.faa.gov>) began in April 2001. In 2001, 0.4 percent of reports were filed electronically compared to 70 percent in 2015. The paper version of FAA Form 5200-7 (mailed to FAA headquarters) declined from 56 percent of all reports in 2001 to 21 percent in 2006 and 1 percent in 2017.

³ More than one type of report was filed for the same strike (many of these had at least one FAA Form 5200-7E (Electronic) report filed).

⁴ Various sources such as news media and Commercial Incident Reports.

Table 6. Person filing report of wildlife strike to civil aircraft, USA¹, 2017 only and 1990–2017.

Person filing report	2017 only		1990-2017	
	Total	% of total	Total	% of total
Airport Operations	10,012	69	84,784	48
Strike reports ²	5,201	52	36,479	43
Carcass found ³	4,811	48	48,305	57
Pilot	1,960	14	37,629	21
Air Transport Operations	1,844	13	20,175	11
Tower	368	3	29,824	17
Other	312	2	4,120	2
Total known	14,496	100	176,532	100
Unknown	1		21,302	
Total	14,497		197,834	

¹ Includes strikes to U.S.-registered aircraft in foreign countries.

² Airport personnel observed strike or reported a strike that had been communicated to them by pilot, tower, or airline.

³ Airport personnel found fresh wildlife remains within 250 feet of a runway centerline or elsewhere on or near airport that appeared to have been struck by aircraft, but no strike was observed or reported by pilot, tower, or airline (FAA Advisory Circular 150/5200-32B).

Table 7. Number of reported wildlife strikes to civil aircraft by type of operator, USA¹, 2017 only and 1990-2017.

Type of operator	2017 only		1990-2017	
	Total	% of total	Total	% of total
Commercial²	8,255	86	126,957	86
General aviation	1,311	14	21,304	14
Business	1,114	12	16,753	11
Government/ Police ³	102	1	1,527	1
Private	95	1	3,024	2
Total known	9,566	100	148,261	100
Unknown⁴	4,931		49,573	
Total	14,497		197,834	

¹ Includes strikes to U.S.-registered aircraft in foreign countries.

² Air carrier, commuter, and air taxi service with 3-letter Operator Code.

³ U.S. Customs and Border Protection (USCBP) and U.S. Coast Guard (USCG) aircraft were respectively involved in 30 percent (464) and 28 percent (438) of the 1,527 Government/police strikes, 1990–2017. For 2017 only, 12 percent (12) and 44 percent (45) of the 102 Government/police strikes involved USCBP and USCG aircraft, respectively.

⁴ Ninety-seven percent (48,305) of the 49,573 strikes involving an unknown operator were “Carcass Found” reports, 1990–2017. For 2017 only, 98 percent (4,811) of the 4,931 strikes involving an unknown operator were “Carcass Found” reports (see Table 6).

Table 8. Number of Part 139-certificated airports¹ and general aviation (GA) airports with reported wildlife strikes and number of strikes reported for these airports, civil aircraft, USA, 1990–2017 (see Figure 6)².

Year	Part 139 airports		GA airports		All USA airports	
	Airports	Strikes	Airports	Strikes	Airports	Strikes
1990	236	1,508	99	163	335	1,671
1991	260	1,989	96	198	356	2,187
1992	255	2,173	107	227	362	2,400
1993	257	2,221	100	218	357	2,439
1994	264	2,220	111	247	375	2,467
1995	261	2,326	120	210	381	2,536
1996	259	2,495	109	194	368	2,689
1997	285	2,908	123	201	408	3,109
1998	292	3,216	145	269	437	3,485
1999	305	3,805	145	257	450	4,062
2000	312	4,465	153	279	465	4,744
2001	317	4,432	151	294	468	4,726
2002	309	4,773	153	307	462	5,080
2003	306	4,650	154	331	460	4,981
2004	307	5,209	177	323	484	5,532
2005	322	5,498	174	330	496	5,828
2006	322	5,923	144	272	466	6,195
2007	327	6,562	164	328	491	6,890
2008	333	6,627	161	308	494	6,935
2009	363	8,012	236	454	599	8,466
2010	375	8,300	216	462	591	8,762
2011	366	8,451	229	498	595	8,949
2012	384	8,918	255	576	639	9,494
2013	381	9,138	272	617	653	9,755
2014	397	11,027	278	698	675	11,725
2015	404	11,124	266	693	670	11,817
2016	403	10,904	260	779	663	11,683
2017	420	11,561	278	809	698	12,370
Total	520	160,435	1,489	10,542	2,009	170,977

¹ There were 526 airports in USA certificated for passenger service under CFR Part 139 regulations in September 2018 (FAA 2018b).

² In addition, 3,864 strikes involving USA-registered aircraft were reported from 308 foreign airports in 109 countries. Furthermore, 3,508 strikes (3,494 bird and 14 bat strikes) were reported in which aircraft was en route (Table 10). An additional 19,449 strikes were reported in which either evidence of strike was discovered on aircraft after landing but phase of flight where strike occurred could not be determined or an airport was not named on reporting form.

Table 9. Reported time of occurrence of wildlife strikes with civil aircraft, USA¹, 1990–2017².

Time of day	Birds		Terrestrial mammals		Bats	
	28-year total	% of total known	28-year total	% of total known	28-year total	% of total known
Dawn	4,215	4	80	4	19	2
Day	75,134	63	562	26	202	26
Dusk	5,161	4	164	8	36	5
Night	35,163	29	1,350	63	534	68
Total known	119,673	100	2,156	100	791	100
Unknown³	71,499		1,910		1,452	
Total	191,172		4,066		2,243	

¹ Includes strikes to U.S.-registered aircraft in foreign countries.

² In addition, 353 strikes with reptiles were reported from 1990–2017: time not reported (283), day (54), night (11), dusk (3), and dawn (2).

³ Of the 75,144 strike reports with “Unknown” time of day (all species), 48,305 (64 percent) were “Carcass Found” reports (Table 6).

Table 10. Reported phase of flight at time of occurrence of wildlife strikes with civil aircraft, USA¹, 1990–2017².

Phase of flight	Birds		Terrestrial mammals ³		Bats	
	28-year total	% of total known	28-year total	% of total known	28-year total	% of total known
Parked	84	<1	2	<1	0	0
Taxi	383	<1	50	2	0	0
Take-off Run	22,074	18	703	30	31	5
Climb	20,866	17	48	2	48	8
Departure ⁴	1,141	1	3	<1	7	1
En Route	3,494	3	0	0	14	2
Arrival ⁴	429	<1	1	<1	0	0
Descent	3,251	3	0	0	16	3
Approach	51,888	41	169	7	439	70
Landing Roll	21,507	17	1,325	57	74	12
Local ⁴	470	<1	10	<1	1	<1
Total known	125,587	100	2,311	100	630	100
Unknown⁵	65,585		1,755		1,613	
Total	191,172		4,066		2,243	

¹ Includes strikes to U.S.-registered aircraft in foreign countries.

² In addition, 353 strikes with reptiles were reported: phase of flight not reported (288), take-off run (25), landing roll (22), taxi (12), and approach (6; pilot missed approach because reptile was on the runway or hit reptile before aircraft touched down).

³ Terrestrial mammal (e.g., deer, coyote) was hit after aircraft lifted off runway or just before touchdown, or pilot had a missed approach because mammal was on runway.

⁴ Phase of flight was determined to be Arrival, Departure, or Local (i.e., pilot conducting “touch-and-go” operations) but exact phase of flight could not be determined.

⁵ Of the 69,241 strike reports with “Unknown” phase of flight (all species), 48,305 (70 percent) were “Carcass Found” reports (Table 6).

Table 11. Number of reported bird strikes to commercial aircraft¹ by height above ground level (AGL), USA², 1990–2017. See Figure 9 for graphic analysis of strike data from 501 to 18,500 feet AGL³.

Height of strike (feet AGL)	All reported strikes			Strikes with damage		
	28-year total	% of total known	% cumulative total ⁴	28-year total	% of total known	% cumulative total ⁴
0	37,256	41	41	1,941	28	28
1-500	27,251	30	71	1,878	27	55
501-1500	9,847	11	82	1,029	15	70
1501-2500	5,181	6	88	628	9	80
2501-3500	3,784	4	92	414	6	86
3501-4500	2,256	2	94	249	4	89
4501-5500	1,615	2	96	188	3	92
5501-6500	1,064	1	97	133	2	94
6501-7500	736	1	98	95	1	95
7501-8500	546	1	99	81	1	96
8501-9500	289	<1	99	37	1	97
9501-10500	387	<1	99	64	1	98
10501-11500	200	<1	100	47	1	99
>11500 ⁵	337	<1	100	101	1	100
Total known	90,749	100		6,885	100	
Unknown height	34,127			2,956		
Total	124,876			9,841		

¹ Air carrier, commuter, and air taxi service with 3-letter Operator Code (see Table 7); Strikes in which height of strike was reported but type of operator was unknown were excluded from analysis.

² Includes strikes to U.S.-registered aircraft in foreign countries.

³ A more detailed analysis of bird strikes by height AGL is provided by Dolbeer (2006b).

⁴ The cumulative percentage of strikes that occur at or below the upper range of the corresponding 1,000-foot interval.

⁵ Twenty-seven strikes involving commercial aircraft (11 with damage to aircraft) were reported at $\geq 20,000$ feet AGL; the highest was 31,300 feet.

Table 12. Number of reported bird strikes to general aviation aircraft¹ by height above ground level (AGL), USA², 1990–2017. See Figure 9 for graphic analysis of strike data from 501 to 12,500 feet AGL³.

Height of strike (feet AGL)	All reported strikes			Strikes with damage		
	28-year total	% of total known	% cumulative total ⁴	28-year total	% of total known	% cumulative total ⁴
0	6,203	37	37	688	16	16
1-500	6,087	36	73	1,405	34	50
501-1500	2,531	15	88	1,093	26	76
1501-2500	1,029	6	94	483	12	88
2501-3500	480	3	96	226	5	93
3501-4500	243	1	98	110	3	96
4501-5500	117	1	99	51	1	97
5501-6500	74	<1	99	36	1	98
6501-7500	58	<1	99	22	1	98
7501-8500	34	<1	100	18	<1	99
8501-9500	20	<1	100	12	<1	99
9501-10500	20	<1	100	13	<1	100
10501-11500	4	<1	100	2	<1	100
>11500 ⁵	29	<1	100	18	<1	100
Total known	16,929	100		4,177	100	
Unknown height	3,073			616		
Total	20,002			4,793		

¹ Private, Business, and Government/Police aircraft (see Table 6); Strikes in which height of strike was reported but type of operator was unknown were excluded from analysis.

² Includes strikes to U.S.-registered aircraft in foreign countries.

³ A more detailed analysis of bird strikes by height AGL is provided by Dolbeer (2006b).

⁴ The cumulative percentage of strikes that occur at or below the upper range of the corresponding 1,000-foot interval.

⁵ Five strikes involving general aviation aircraft (4 with damage to aircraft) were reported at $\geq 20,000$ feet AGL; the highest was 24,000 feet.

Table 13. Civil aircraft components reported as being struck and damaged by wildlife, USA¹, 1990–2017.

Aircraft component	Birds (28-year total)				Terrestrial mammals (28-year total)			
	Number struck	% of total	Number damaged	% of total	Number struck	% of total	Number damaged	% of total
Windshield	26,167	16	1,087	6	9	<1	17	1
Nose	23,381	14	1,171	7	116	4	109	5
Wing/rotor	22,703	14	4,229	24	316	11	325	16
Other	21,248	13	1,415	8	384	13	290	14
Radome	19,863	12	1,654	9	19	1	17	1
Engine(s) ²	19,401	12	4,787	27	182	6	177	9
Fuselage	19,070	12	764	4	147	5	154	8
Landing gear	7,244	4	573	3	1,355	46	494	24
Propeller	3,454	2	287	2	339	11	306	15
Tail	2,065	1	722	4	62	2	84	4
Light	1,074	1	762	4	48	2	54	3
	165,670	100	17,451	100	2,977	100	2,027	100

¹ Includes strikes to U.S.-registered aircraft in foreign countries.

² For birds, 19,401 engines were reported as struck in 18,527 strike events involving engines (17,682 events with one engine struck, 823 with two engines struck, 15 with three engines struck, and 7 with four engines struck). A total of 4,787 engines was damaged in 4,634 bird-strike events with engine damage (4,484 events with one engine damaged, 148 with two engines damaged, 1 with three engines damaged, and 1 with four engines damaged). For terrestrial mammals, 182 engines were reported as struck in 172 strike events (162 events with one engine struck and 10 with two engines struck). A total of 177 engines was damaged in 158 terrestrial mammal strike events with engine damage (139 events with one engine damaged and 19 with two engines damaged). Some engines were damaged without being struck when the landing gear collapsed.

³ In addition, bat strikes had 1,145 and 18 components reported as struck and damaged, respectively: radome/nose (408, 2), windshield (188, 3), engine (75, 4), propeller (5, 0), wing/rotor (220, 7), fuselage (104, 0), tail (12, 0), other (84, 0), landing gear (43, 0), light (6, 2). For reptile strikes, there were 65 and 7 components reported struck and damaged, respectively: windshield (1, 1), wing/rotor (2, 2), fuselage (1, 1), landing gear (53, 1), tail (1, 1), other (7, 1).

Table 14. Number of civil aircraft with reported damage resulting from wildlife strikes, USA¹, 1990–2017. See Tables 1 - 4 and Figures 2 – 4, 11, and 16 for trends in damaging strikes, 1990–2017.

Damage category ³	Reported strikes					
	Birds		Terrestrial mammals		Total (all species) ²	
	28-year total	% of total ⁴	28-year total	% of total ⁴	28-year total	% of total ⁴
None	118,787	62	1,059	26	120,865	61
Unknown	57,641	30	1,891	47	61,089	31
Damage	14,744	8	1,116	27	15,880	8
Minor	7,527	4	559	14	8,096	4
Uncertain	3,622	2	104	3	3,732	2
Substantial	3,556	2	422	10	3,982	2
Destroyed	39	<1	31	1	70	<1
Total	191,172	100	4,066	100	197,834	100

¹ Includes strikes to U.S.-registered aircraft in foreign countries.

² Included in totals are 2,243 and 353 strikes involving bats and reptiles, respectively. For bats, 963 reports indicated no damage, 1,263 failed to indicate if damage occurred, and 17 indicated damage (9 minor, 5 uncertain level, 3 substantial [caused by megabats at foreign airports]). For reptiles, 56 reports indicated no damage, 353 failed to indicate if damage occurred, and 3 indicated damage (1 minor, 1 uncertain level, 1 substantial).

³ The damage codes and descriptions are from the International Civil Aviation Organization (1989): Minor = the aircraft can be rendered airworthy by simple repairs or replacements and an extensive inspection is not necessary; Uncertain = the aircraft was damaged, but details as to the extent of the damage are lacking; Substantial = the aircraft incurs damage or structural failure that adversely affects the structure strength, performance, or flight characteristics of the aircraft and that would normally require major repair or replacement of the affected component (specifically excluded are bent fairings or cowlings; small dents or puncture holes in the skin; damage to wing tips, antenna, tires, or brakes; and engine blade damage not requiring blade replacement); Destroyed = the damage sustained makes it inadvisable to restore the aircraft to an airworthy condition.

⁴ The percentage of strikes causing damage is calculated using the total strikes reported as the divisor, including the 61,089 reports that did not indicate if damage occurred or not (Unknown). “Carcass found” reports (see Table 6) comprised 48,305 (79 percent) of these 61,089 reports. If the Unknown reports are excluded from the calculations, then 11, 51, and 12 percent of the strikes caused damage for birds, terrestrial mammals, and all species, respectively.

Table 15. Reported effect-on-flight of wildlife strikes to civil aircraft, USA¹, 1990–2017. See Figure 11 for trend in strikes with a negative effect-on-flight, 1990-2017.

Effect-on-flight ³	Reported strikes					
	Birds		Terrestrial mammals		Total ²	
	28-year total	% of total ⁴	28-year total	% of total ⁴	28-year total	% of total ⁴
None	100,841	53	1,000	25	102,685	52
Unknown	79,404	42	2,299	57	83,432	42
Negative effect	10,927	6	767	19	11,717	6
Precautionary landing	6,096	3	116	3	6,222	3
Aborted take-off	2,183	1	242	6	2,427	1
Engine shutdown	425	<1	35	1	460	<1
Other	2,223	1	374	9	2,608	1
Total	191,172	100	4,066	100	197,834	100

¹ Includes strikes to U.S.-registered aircraft in foreign countries.

² Included in totals are 2,243 and 353 strikes involving bats and reptiles, respectively. For bats, 793 reports indicated no effect-on-flight, 1,438 failed to indicate if an effect-on-flight occurred, and 12 indicated a negative effect (9 precautionary landings, 3 “Other”). For reptiles, 51 reports indicated no effect-on-flight, 291 failed to indicate if an effect-on-flight occurred, and 11 indicated a negative effect (1 precautionary landing, 2 aborted take-off, 8 “Other”).

³ Effect-on-flight: None = flight continued as scheduled, although delays and other cost caused by inspections or repairs may have been incurred after landing; Aborted take-off = pilot aborted take-off on departure runway after initiating take-off run (aircraft may have become airborne but pilot landed on departing runway without doing a “go around”); Precautionary landing (includes “declared emergency” landings) = pilot completed take-off but returned to land at departure airport or landed at an “other-than-destination” airport after strike; Engine shut down = pilot shut down engine or engine stopped running because of strike; Other = miscellaneous effects, such as reduced speed because of shattered windshield, flight delays, or crash landing; Unknown = report did not give sufficient information to determine an effect-on-flight (Dolbeer et al. 2000).

⁴ The percentage of strikes causing negative effect-on-flight is calculated using the total strikes reported as the divisor, including the 83,432 reports that did not indicate if a negative effect occurred or not (Unknown). “Carcass found” reports (see Table 6) comprised 48,305 (58 percent) of these 83,432 reports. If the Unknown reports are excluded from the calculations, then 10, 43, and 10 percent of the strikes caused a negative effect-on-flight for birds, terrestrial mammals, and all species, respectively.

Table 16. Number of reported incidents where pilot made a precautionary or emergency landing after striking birds during departure in which fuel was jettisoned or burned (circling pattern) to lighten aircraft weight or in which an overweight (greater than maximum landing weight) landing was made (no fuel jettison or burn), civil aircraft, USA, 1990–2017¹. See Figure 12 for trend in incidents, 1990–2017.

Action taken after bird strike on departure	Number of incidents	Comments and number of incidents by aircraft model
Fuel jettison	58	A mean of 94,358 lbs (13,876 gallons) of fuel jettisoned per incident (range 300 – 270,000 lbs; 44 - 39,706 gallons). Aircraft: B-747 (21); B-767 (8); B-727 (6); DC-10/MD-11 (8); B-777 (3); Learjet 31/35 (3); Airbus 320, Gulfstream 200, Gulfstream G150, L-1011, Lockheed P38, CL601, DA-2000, and unknown (1 each)
Fuel burn	83	Aircraft: EMB-120/145/170/190 (13); B-737 (10); A-319 to A330 (14); CL-RJ 100/700/900 (7); Learjet 24/60 (5); MD-80/88 and CitationJet (3 each); B-727, B-747, DHC8-Dash 8, and PA-28 (2 each); and 20 other aircraft types with 1 each.
Overweight landing	105	Aircraft: B-737 (31); A-320/330 (21); B-757 (15); MD-80/83 (12); B-767 (9); CRJ-100 to 700 (4); EMB-145/170 (3), MD-80 to 83 (12); A-300, MD-11, and C-500/600 (2 each); B-747: CL-RJ 900; DA-50 Falcon and Dornier 328 (1 each).
Total	246	A mean of 8.8 (range 0 – 21) incidents (fuel jettison, fuel burn, or overweight landing) per year, 1990 – 2017.

¹ Includes strikes to U.S.-registered aircraft in foreign countries.

Table 17. Indicated airspeed (nautical miles/hour [knots])¹ at time pilot aborted take-off after striking or observing a bird or other wildlife species on runway, civil aircraft, USA², 1990–2017. See Figure 13 for trend in high-speed aborted take-offs at ≥ 100 knots caused by birds or other wildlife, 1990–2017.

Aircraft speed (knots)	Commercial aircraft ³		General aviation aircraft ⁴		All aircraft ^{5, 6}	
	28-year total	% of total known	28-year total	% of total known	28-year total	% of total known
1-49	26	3	91	16	119	8
50-99	405	48	347	61	757	53
≥ 100	409	49	130	23	542	38
Total known	840	100	568	100	1,418	100
Unknown	619		374		1,009	
Total	1,459		942		2,427	

¹ A speed of 100 knots equals 185 kilometers/hour (115 miles/hour).

² Includes strikes to U.S.-registered aircraft in foreign countries.

³ Air carrier, commuter, and air taxi service with 3-letter identifying code (see Table 7).

⁴ Business, Private, or Government aircraft (see Table 7).

⁵ Included in totals are 26 aborted take-offs in which type of operator was unknown. For these 23 events, the speed was unreported (16), 1-49 knots (2), 50-99 knots (5), and ≥ 100 knots (3).

⁶ Includes 6 incidents in which effect-on-flight was classified as “Engine shutdown” (Table 15) but pilot also aborted take-off.

Table 18. Total reported strikes, strikes causing damage, strikes having a negative effect-on-flight (EOF), strikes involving >1 animal, aircraft downtime, and costs by identified wildlife species, civil aircraft, USA¹, 1990–2017 (page 1 of 23).

Wildlife group or species	28-year totals (1990–2017)					
	Number of reported strikes				Reported economic losses ²	
	Total	With damage	With neg. EOF	With multiple animals ³	Aircraft down time (hrs)	Reported costs (\$)
Birds						
Loons	52	31	20		6,188	3,273,274
Loons	2	1	1			
Common loon	37	23	14		5,669	3,119,160
Red-throated loon	12	6	5		327	152,751
Pacific loon	1	1			192	1,363
Grebes	137	30	16	15	2,132	4,727,996
Grebes	11	2	1	2	200	21,720
Eared grebe	19	2		1	154	222,274
Western grebe	42	14	9	9	1,587	2,789,925
Pied-billed grebe	43	5	1		45	24,823
Horned grebe	14	4	3	1	74	137,755
Red-necked grebe	4	2	2	1		
Clark's grebe	3	1		1	72	1,531,500
Great crested grebe	1					
Albatrosses/shearwaters	86	9	6	5	197	81,678
Laysan albatross	37	8	5	1	197	81,678
Black-footed albatross	5	1				
Bonin petrel	12			4		
Northern fulmar	1					
Shearwaters	1					
Wedge-tailed shearwater	15		1			
Townsend's shearwater	11					
Storm-petrels	1					
Fork-tailed storm-petrel	2					
Bnd-rumped storm-petrel	1					
Tropicbirds	29	15	11		235	139,094
Tropicbirds	8	6	4		148	62,120
White-tailed tropicbird	18	8	6		87	69,223
Red-tailed tropicbird	3	1	1			7,750
Pelicans	99	48	37	17	4,965	11,090,859
Pelicans	6	2			108	21,741
Australian pelican	1	1	1			
Brown pelican	70	30	24	8	497	470,604
American white pelican	22	15	12	9	4,360	10,598,514
Red-footed booby	1					

Wildlife Strikes to Civil Aircraft in the United States, 1990–2017

Table 18. Continued (Page 2 of 23)

Wildlife group or species	28-year totals (1990–2017)					
	Number of reported strikes				Reported economic losses ²	
	Total	With damage	With neg. EOF	With multiple animals ³	Aircraft down time (hrs)	Reported costs (\$)
Cormorants	161	56	41	27	3,343	6,323,129
Cormorants	3	1			12	15,530
Great cormorant	2	1		2		
Dbl-crested cormorant	153	53	40	25	3,307	6,307,599
Pelagic cormorant	2					
Brandt's cormorant	1	1	1		24	
Anhinga	38	19	13	5	254	986,987
Frigatebirds	20	8	5		89	35,197
Great frigatebird	12	4	3		69	28,885
Magnificent frigatebird	8	4	2		20	6,312
Herons, egrets, bitterns	1,826	210	223	229	9,372	17,816,131
Herons, egrets, bitterns	5		1			
Herons	55	12	10	2	99	4,329
Gray heron	2	1	1			
Great blue heron	430	84	68	8	4,075	8,572,579
Blk-crowned night-heron	99	9	4	5	111	380,656
Little blue heron	10					311
Green heron	27	1	1	1		
Ylw-crowned night-heron	54	10	7	5	186	808,470
Tricolored heron	6		2			
Purple heron	1					
American bittern	11	3	2		646	54,910
Yellow bittern	148		2	12		
Least bittern	2					
Egrets	350	33	53	90	3,624	4,599,404
Cattle egret	481	39	59	93	355	861,960
Great egret	108	14	10	12	177	2,484,595
Intermediate egret	1					
Snowy egret	36	4	3	1	99	48,918
Storks	22	7	4	4	39	22,862
White stork	1	1				
Wood stork	21	6	4	4	39	22,862
Ibises, spoonbills	57	15	15	10	165	1,134,929
Ibises	6		1	1		
Glossy ibis	4	1	1	1		2,136
White ibis	25	3	6	2	134	61,082
White-faced ibis	18	10	5	6	19	1,059,299
Roseate spoonbill	4	1	2		12	12,411

Wildlife Strikes to Civil Aircraft in the United States, 1990–2017

Table 18. Continued (Page 3 of 23)

Wildlife group or species	28-year totals (1990–2017)					
	Number of reported strikes				Reported economic losses ²	
	Total	With damage	With neg. EOF	With multiple animals ³	Aircraft down time (hrs)	Reported costs (\$)
Waterfowl	5,523	2,199	1,143	1,875	178,652	251,387,410
Ducks, geese, swans	141	69	32	56	823	1,410,444
Ducks	858	293	138	270	10,224	8,800,390
American wigeon	84	31	13	26	5,061	1,971,414
Northern pintail	175	80	41	75	2,374	8,547,510
Green-winged teal	81	17	9	23	906	1,117,249
Blue-winged teal	62	21	9	13	408	1,221,046
Eurasian wigeon	1			1		
Mallard	1,003	211	126	234	13,778	20,323,998
Common eider	4	2	1	1		
Ring-necked duck	35	12	7	9	1,624	119,100
Greater scaup	14	4	3	5		
Wood duck	66	19	6	11	542	169,755
Muscovy duck	4	1	2		120	603,818
Common goldeneye	8	2	1			2,430
Red-breasted merganser	9	1		1	3	
Hooded merganser	14	5		2	54	263,711
Common merganser	5	2	2	1	120	3,758
Northern shoveler	91	36	10	30	2,300	2,854,993
Gadwall	86	30	14	26	803	9,919,019
Canvasback	25	13	5	9	703	2,615,109
American black duck	64	7	3	19	2,604	1,109,221
Mottled duck	28	4	4	6	25	
Lesser scaup	61	23	14	21	1,830	276,933
Ruddy duck	75	16	6	11	173	121,973
Redhead	12	7	2	5	101	231,811
Bufflehead	23	2	4	1	376	12,860
Long-tailed duck	6	4	3	1	20	49,157
Philippine duck	1	1	1	1	96	11,857,824
Blk-bellied whistling-duck	14	3	1	1	48	
Cinnamon teal	9	5	2	2	42	34,243
White-winged scoter	3	2	2	1	1,400	508,260
Hawaiian duck	15			5		
Harlequin duck	1					
Barrow's goldeneye	3					
Surf scoter	2					
Geese	393	220	97	143	27,992	3,342,493
Snow goose	163	122	63	89	13,994	34,909,331

Wildlife Strikes to Civil Aircraft in the United States, 1990–2017

Table 18. Continued (Page 4 of 23)

Wildlife group or species	28-year totals (1990–2017)					
	Number of reported strikes				Reported economic losses ²	
	Total	With damage	With neg. EOF	With multiple animals ³	Aircraft down time (hrs)	Reported costs (\$)
Canada goose	1,716	845	479	704	87,630	130,889,859
Brant	44	14	6	12	126	100,129
Grter white-fronted goose	70	45	20	40	1,604	6,149,803
Emperor goose	2	1				10,141
Cackling goose	16	9	2	5	179	204,544
Hawaiian goose	2	1	1	1	9	
Egyptian goose	1			1		
Swans	2	1				
Mute swan	9	2	1	2		
Tundra swan	20	14	11	10	488	482,885
Trumpeter swan	2	2	2	1	72	1,152,200
Hawks, eagles, vultures	6,892	1,611	1,048	224	143,451	119,994,793
Unknown birds of prey	42	18	7	1	2,559	23,680
New World Vultures	334	195	100	27	27,090	13,804,804
Black vulture	181	112	65	13	14,927	6,373,279
Turkey vulture	755	381	241	42	45,056	14,687,177
Osprey	400	89	51	6	3,668	1,341,964
Kites	3					
White-tailed kite	45	4	2	1	46	6,075,000
Black kite	3	2	1			
Mississippi kite	11					
Swallow-tailed kite	4		1		1	37
Eagles	9	3	2	1		
Bald eagle	269	98	77	17	8,907	26,835,956
White-bellied sea-eagle	1	1	1			
Golden eagle	24	5	5	1	3,724	974,808
Wedge-tailed eagle	1	1	1			
Hawks	1,427	271	194	35	14,481	5,517,046
Northern goshawk	3					
Red-tailed hawk	2,693	365	264	67	18,512	32,994,970
Rough-legged hawk	98	8	3	1	21	65,904
Red-shouldered hawk	66	6	7		210	4,038
Swainson's hawk	156	22	12	3	1,197	644,477
Eurasian sparrowhawk	2					
Sharp-shinned hawk	34	2		1	1,048	413,106
Cooper's hawk	116	6	6	1	40	12,000
Ferruginous hawk	39	5	1		88	3,766,905
Broad-winged hawk	29	11	3	3	1,607	162,928

Wildlife Strikes to Civil Aircraft in the United States, 1990–2017

Table 18. Continued (Page 5 of 23)

Wildlife group or species	28-year totals (1990–2017)					
	Number of reported strikes				Reported economic losses ²	
	Total	With damage	With neg. EOF	With multiple animals ³	Aircraft down time (hrs)	Reported costs (\$)
Harris's hawk	4					
Hawaiian hawk	1		1		2	
White-tailed hawk	3					
Eurasian buzzard	4	1			26	
Northern harrier	132	3	2	3	1	284,716
Old world vultures	2	1		1		
Lappet-faced vulture	1	1	1		240	6,012,000
Falcons and Caracaras	6,260	75	129	273	2,203	3,720,347
Falcons and Caracaras	56	4	5	2	82	56,394
Falcons, kestrels	5	1	1	1	13	511
Peregrine falcon	403	27	19	19	342	900,401
Gyr Falcon	2					
Merlin	115	2	4	5	28	535,792
Prairie falcon	30	1	3	2		6,188
American kestrel	5,622	35	94	244	1,697	2,221,062
Eurasian kestrel	5	1	1			
Crested caracara	21	4	2		41	
Yellow-headed caracara	1					
Gallinaceous birds	316	70	57	64	3,512	6,896,146
Grouse	2	1				
Greater sage-grouse	38	12	6	15	556	505,092
Sharp-tailed grouse	17	1	2	3	24	781
Ruffed grouse	1					
Spruce grouse	1					
Ptarmigans	3	1	1	2	18	71,100
Willow ptarmigan	6	3	1	4	207	139,077
Rock ptarmigan	1	1				
Quails, pheasants	1	1				18,167
Quails	10		3	2		
Northern bobwhite	14	3	3	2	93	8,244
Scaled quail	5					
Gambel's quail	1			1		
Pheasants	4					
Ring-necked pheasant	88	18	13	6	883	107,909
Red-legged partridge	1					
Gray partridge	28	4	5	12	44	5,614,235
Chukar	4		1	1		
Gray francolin	3					

Wildlife Strikes to Civil Aircraft in the United States, 1990–2017

Table 18. Continued (Page 6 of 23)

Wildlife group or species	28-year totals (1990–2017)					
	Number of reported strikes				Reported economic losses ²	
	Total	With damage	With neg. EOF	With multiple animals ³	Aircraft down time (hrs)	Reported costs (\$)
Black francolin	5					
Helmeted guineafowl	2	1		2		
Wild turkey	81	24	22	14	1,687	431,541
Cranes	151	61	39	42	2,487	412,417
Cranes	2					
Sandhill crane	148	60	39	42	2,439	352,962
Whooping crane	1	1			48	59,455
Rails, gallinules	412	77	39	18	4,590	8,025,172
Rails	13	1	1	2		
Sora	61	5	1	4	131	112,215
Common gallinule	7	1	1		24	1,283
American coot	294	69	34	12	4,354	7,881,592
Eurasian coot	1					
Purple gallinule	5	1	1		72	30,082
Virginia rail	20		1		9	
Clapper rail	10					
Yellow rail	1					
Shorebirds	9,165	172	203	1,260	5,845	6,893,720
Shorebirds	33	1		9	5	
American oystercatcher	25			2		
Plovers, lapwings	1			1		
Plovers	82	3	4	13	24	
European golden-plover	5			1		
American golden-plover	190	6	6	47	86	116,902
Black-bellied plover	154	8	5	24	28	210,847
Snowy plover	3			2	1	
Killdeer	5,720	56	82	543	1,630	4,103,079
Pacific golden-plover	1,073	13	19	145	319	372,754
Semipalmated plover	105		1	32		
Piping plover	2	1		1	2	225
Wilson's plover	3					
Northern lapwing	1	1	1	1	25	
Southern lapwing	4	1	1			10,648
Sandpipers, curlews,	306	15	27	90	182	206,028
Upland sandpiper	280	8	8	25	18	2,593
Spotted sandpiper	31	2	2	5	1	
Willet	6			2		
Common snipe	6					

Wildlife Strikes to Civil Aircraft in the United States, 1990–2017

Table 18. Continued (Page 7 of 23)

Wildlife group or species	28-year totals (1990–2017)					
	Number of reported strikes				Reported economic losses ²	
	Total	With dam- age	With neg. EOF	With multiple animals ³	Aircraft down time (hrs)	Reported costs (\$)
American woodcock	111	3	3	7	20	11,984
Dunlin	95	8	7	33	658	330,516
Baird's sandpiper	38	1		4	18	94,119
Western sandpiper	173	6	7	100	1,517	179,871
Pectoral sandpiper	41	3	3	12	22	168,231
Sanderling	33	1	3	10	6	
Buff-breasted sandpiper	49	1		9		
Ruddy turnstone	27			4		
Bar-tailed godwit	1					
Least sandpiper	170	2	5	42	8	6,000
Semipalmated sandpiper	96		1	38	1	517
Lesser yellowlegs	18	3		4	2	
Short-billed dowitcher	15	3		4	6	10,680
Hudsonian godwit	6	1	1	2	96	34,561
Solitary sandpiper	8	1		2		
Greater yellowlegs	15	5	1	2	120	62,306
Long-billed dowitcher	10			3	1	
Red knot	4		1			
White-rumped sandpiper	11			1		
Black turnstone	1					
Marbled godwit	4	1	1	1	48	170,285
Wilson's snipe	123	6	4	8	40	18,272
Rock sandpiper	2			2		
South American snipe	1					
Stilt sandpiper	1					
Purple sandpiper	1					
Eurasian curlew	1					
Whimbrel	20	2	1	4	360	54,500
Long-billed curlew	8	1	1	1	504	715,360
Red-necked phalarope	12	2	2	4	60	
Wilson's phalarope	19	6	5	12	37	13,443
Red phalarope	1					
American avocet	7	1	1	4		
Black-necked stilt	12			4		
Double-striped thick-knee	1					
Jaegers	7					
Parasitic jaeger	3					
Long-tailed jaeger	4					

Wildlife Strikes to Civil Aircraft in the United States, 1990–2017

Table 18. Continued (Page 8 of 23)

Wildlife group or species	28-year totals (1990–2017)					
	Number of reported strikes				Reported economic losses ²	
	Total	With damage	With neg. EOF	With multiple animals ³	Aircraft down time (hrs)	Reported costs (\$)
Gulls	11,472	1,514	1,278	2,286	64,837	60,114,095
Gulls	6,921	1,132	927	1,650	44,759	30,162,445
Herring gull	1,357	126	118	143	3,110	5,055,603
Mew gull	72	8	6	12	49	106,563
Ring-billed gull	1,718	131	123	287	8,953	4,908,715
Glaucous-winged gull	132	25	16	16	308	1,818,108
Great black-backed gull	120	12	9	11	223	2,017,127
Franklin's gull	167	8	15	52	71	211,162
Laughing gull	519	21	24	56	761	892,087
Bonaparte's gull	50	2	4	12		92,430
Lesser black-backed gull	6	2	1	1		
Western gull	142	17	9	11	232	2,062,695
California gull	218	22	20	28	5,134	710,707
Heermann's gull	2			1		
Black-headed gull	8	1	1		250	8,853
Iceland gull	3					
Yellow-legged gull	3	3	3	3	456	11,708,951
Glaucous gull	33	3	2	3	513	346,000
Vega gull	1	1			18	12,647
Terns, kittiwakes, puffins	234	10	9	42	145	700,397
Terns	55	2	1	18	1	
White-winged tern	2			1		
Little tern	2			1		
Caspian tern	34	2	1	2	24	603,427
Common tern	24	1		3		80,100
Sandwich tern	2					
Gull-billed tern	5					
Black tern	4				2	
White tern	13	1	2	3	34	
Arctic tern	6	1		2		
Roseate tern	1					
Forster's tern	14		1	3	5	200
Least tern	24			3		
Black noddy	7			3		
Brown noddy	8		1	1		
Royal tern	7	1	1	1	30	
Sooty tern	5	1	1		48	16,565
Black-legged kittiwake	3					

Wildlife Strikes to Civil Aircraft in the United States, 1990–2017

Table 18. Continued (Page 9 of 23)

Wildlife group or species	28-year totals (1990–2017)					
	Number of reported strikes				Reported economic losses ²	
	Total	With dam- age	With neg. EOF	With multiple animals ³	Aircraft down time (hrs)	Reported costs (\$)
Red-legged kittiwake	1					
Black skimmer	15	1		1		
Pigeon guillemot	1					
Puffins	1		1		1	105
Pigeons, doves	14,253	535	706	2,565	30,124	23,390,755
Pigeons, doves	34	4	5	12	1,637	662
Pigeons	34	2	2	5	6	
Common wood-pigeon	6			1		
Band-tailed pigeon	21	7	1	3	184	196,395
Rock pigeon	3,202	256	287	954	14,656	12,387,946
Picazuro pigeon	1					
White-crowned pigeon	1			1		
Doves	1,101	47	94	243	643	645,242
Eurasian collared dove	31	1	1	6	24	1,035
Mourning dove	9,157	206	293	1,290	11,497	9,787,722
Spotted dove	211	4	12	10	142	355,386
Zebra dove	323	4	11	31	1,200	14,027
Inca dove	16			1		
Sundra collared dove	7					
White-winged dove	86	3		8	103	2,340
Common ground-dove	12					
Zenaida dove	8	1			32	
Ruddy ground-dove	1					
Eared dove	1					
Parrots	28			4	5	7,757
Parrots	3			1		
Budgerigar	16			1		
Monk parakeet	4			1		
Olive-throated parakeet	1			1		
Nanday parakeet	3				5	7,757
Red-masked parakeet	1					
Cuckoos, roadrunners	87	13	3	8	735	250,269
Cuckoos	19	3		2	684	182,987
Yellow-billed cuckoo	56	9	3	6	50	67,282
Common cuckoo	1					
Black-billed cuckoo	8	1			1	
Philippine drongo-cuckoo	1					
Greater roadrunner	2					

Wildlife Strikes to Civil Aircraft in the United States, 1990–2017

Table 18. Continued (Page 10 of 23)

Wildlife group or species	28-year totals (1990–2017)					
	Number of reported strikes				Reported economic losses ²	
	Total	With damage	With neg. EOF	With multiple animals ³	Aircraft down time (hrs)	Reported costs (\$)
Owls	3,105	161	103	37	3,652	9,922,699
Owls	336	34	21	6	1,484	519,474
Barn owl	1,339	48	33	20	483	3,141,036
Snowy owl	259	20	14	1	873	1,904,073
Little owl	1					
Short-eared owl	566	13	14	4	133	1,554,457
Long-eared owl	19	3	1		24	53,400
Northern saw-whet owl	7	1			96	
Burrowing owl	261	4	5	4	9	835
Barred owl	31	1	1			169
Northern pygmy-owl	1					
Great gray owl	2					
Eastern screech-owl	5	2			24	13,211
Western screech-owl	3					
Great horned owl	274	35	14	2	526	2,736,044
Northern hawk owl	1					
Goatsuckers, nightjars	775	4	3	41	83	200
Nightjars	15					
Eastern whip-poor-will	10			2		
Common poorwill	12			1		
Lesser nighthawk	22			2	12	
Chuck-will's-widow	14		1		1	
Common nighthawk	690	4	2	36	70	200
Common pauraque	10					
Nacunda nighthawk	1					
Antillean nighthawk	1					
Swifts	929	11	15	73	1,283	38,899
Swifts	19	1		1		
Black swift	3					
Chimney swift	786	8	13	69	1,254	38,899
Common swift	13	1		1		
Vaux's swift	53				24	
White-throated swift	55	1	2	2	5	
Hummingbirds	73			1	2	
Hummingbirds	3					
Ruby-thrted hummingbird	40					
Rufous hummingbird	13			1		
Anna's hummingbird	11				2	

Wildlife Strikes to Civil Aircraft in the United States, 1990–2017

Table 18. Continued (Page 11 of 23)

Wildlife group or species	28-year totals (1990–2017)					
	Number of reported strikes				Reported economic losses ²	
	Total	With dam- age	With neg. EOF	With multiple animals ³	Aircraft down time (hrs)	Reported costs (\$)
Blk-chinned hummingbird	3					
Allen's hummingbird	1					
Calliope hummingbird	2					
Belted kingfisher	12					
Woodpeckers	262	20	7	11	547	274,890
Woodpeckers	14	1	1		1	
Northern flicker	131	8	1	2	296	126,441
Yellow-bellied sapsucker	94	9	2	9	239	129,639
Hairy woodpecker	3					
Red-naped sapsucker	5	2	2			18,810
Downy woodpecker	7		1		1	
Red-bellied woodpecker	5				10	
Red-breasted sapsucker	2					
Red-headed woodpecker	1					
Unidentified passiformes	930	31	22	64	230	190,460
Flycatchers	864	8	8	61	17	18,640
Spotted flycatcher	1					
Blue-and-white swallow	1					
Black redstart	1					
Tyrant flycatchers	38			6	1	836
Eastern wood-pewee	17			4		
Gray kingbird	8					
Great crested flycatcher	15			1		
Eastern kingbird	59	1	1	5		13,348
Scissor-tailed flycatcher	221	1	4	12		673
Acadian flycatcher	7			1		
Say's phoebe	15					
Western kingbird	318	3	2	21	3	1,578
Ash-throated flycatcher	9					
Great kiskadee	1					
Western wood-pewee	5					
Sulphur-bellied flycatcher	3					
Eastern phoebe	27	1		2		
Yellow-bellied flycatcher	17			2		631
Least flycatcher	18			2		
Hammond's flycatcher	10				1	
Pacific-slope flycatcher	29			1	10	1,553
Gray flycatcher	3			1	1	21

Wildlife Strikes to Civil Aircraft in the United States, 1990–2017

Table 18. Continued (Page 12 of 23)

Wildlife group or species	28-year totals (1990–2017)					
	Number of reported strikes				Reported economic losses ²	
	Total	With damage	With neg. EOF	With multiple animals ³	Aircraft down time (hrs)	Reported costs (\$)
White-crested elaenia	3	1				
Willow flycatcher	6			1		
Alder flycatcher	24	1		2		
Cordilleran flycatcher	2				1	
Dusky flycatcher	3		1			
Couch's kingbird	2					
Thick-billed kingbird	1					
Larks	4,738	21	51	720	1,464	981,920
Larks	8			1		
Eurasian skylark	93			4	1	
Horned lark	4,636	21	51	715	1,463	981,920
Hume's short-toed lark	1					
Swallows	9,847	53	149	1,997	976	635,520
Swallows	1,150	9	46	335	143	134,740
Purple martin	215	11	4	48	314	112,112
Bank swallow	507	2	8	186	47	11,405
Barn swallow	5,293	24	63	946	375	88,781
Cliff swallow	1,750	5	18	265	72	285,550
Tree swallow	793		8	198	23	2,933
Violet-green swallow	26	1		1		
N. rough-winged swallow	84	1	1	9	2	
Cave swallow	29		1	9		
Black drongo	14			3		
Starlings, mynas	4,655	138	203	1,529	3,532	7,107,252
European starling	4,540	135	197	1,500	3,489	7,107,252
Mynas	1	1				
Common myna	114	2	6	29	43	
Crows, ravens	764	71	62	89	10,494	2,916,674
Crows, ravens	2	1		1		
Crows	205	21	12	34	26	125,283
American crow	492	35	42	49	7,190	2,031,804
Carrion crow	3	1			35	5,105
Hooded crow	1	1	1			
Northwestern crow	7			1		
Rook	1					
Fish crow	2					
Ravens	6	2	1		54	20,685
Common raven	45	10	6	4	3,189	733,797

Wildlife Strikes to Civil Aircraft in the United States, 1990–2017

Table 18. Continued (Page 13 of 23)

Wildlife group or species	28-year totals (1990–2017)					
	Number of reported strikes				Reported economic losses ²	
	Total	With dam- age	With neg. EOF	With multiple animals ³	Aircraft down time (hrs)	Reported costs (\$)
Jays, Magpies	57	3	2	6	2	918
Blue jay	30			1	1	
Gray jay	1					
Yellow-billed magpie	8			2		
Black-billed magpie	18	3	2	3	1	918
Chickadees, nuthatches	38	1		9		
Chickadees	1					
Black-capped chickadee	24	1		6		
Mountain chickadee	3			1		
Gray-headed chickadee	1			1		
Carolina chickadee	2			1		
Bushtit	2					
Nuthatches and creepers	1					
White-breasted nuthatch	2					
Red-breasted nuthatch	2					
Red-vented bulbul	4			1		
Wrens	166	3	5	16	34	32,295
Wrens	55	1	3	9		
Marsh wren	27	1	2	2	32	31,769
House wren	46	1		3	1	526
Carolina wren	10			1		
Rock wren	2					
Cactus wren	4					
Winter wren	13				1	
Bewick's wren	2					
Sedge wren	7			1		
Thrashers, mimics	363	5	3	21	174	2,081,131
Brown thrasher	24	1		1	103	2,070,840
Sage thrasher	4					
Curve-billed thrasher	2					
Long-billed thrasher	1			1		
Mockingbirds	4			1		
Northern mockingbird	123	2	2	3	1	
Tropical mockingbird	1					
Gray catbird	204	2	1	15	70	10,291
Thrushes	2,039	140	63	144	5,297	7,449,547
Thrushes	50	3	1	2	7	33,048
Western bluebird	10	1	1	1	21	1,189

Wildlife Strikes to Civil Aircraft in the United States, 1990–2017

Table 18. Continued (Page 14 of 23)

Wildlife group or species	28-year totals (1990–2017)					
	Number of reported strikes				Reported economic losses ²	
	Total	With damage	With neg. EOF	With multiple animals ³	Aircraft down time (hrs)	Reported costs (\$)
Swainson's thrush	253	16	5	20	403	2,631,902
Redwing	1					
American robin	1,279	95	43	85	3,964	4,597,261
Song thrush	1			1		
Hermit thrush	222	8	4	11	741	35,252
Eastern bluebird	17			2		
Gray-cheeked thrush	37		2	3	2	
Varied thrush	57	11	2	7	48	36,213
Wood thrush	44	2	1	5	60	114,683
Mountain bluebird	34			5		
Veery	33	3	4	2	51	
Townsend's solitaire	1	1				
Eur. warblers, wrentits	2					
Garden warbler	1					
Wrentit	1					
Blue-gray gnatcatcher	37		1	2	2	
Kinglets	171		2	10	8	311
Golden-crowned kinglet	45			2		
Ruby-crowned kinglet	126		2	8	8	311
Pipits	201	1	3	35	28	
Meadow pipit	1					
American pipit	192	1	3	35	28	
Sprague's pipit	7					
Olive-backed pipit	1					
Waxwings	299	7	5	64	332	364,259
Bohemian waxwing	3			2		
Cedar waxwing	296	7	5	62	332	364,259
Shrikes	38		2	1		
Northern shrike	1					
Loggerhead shrike	37		2	1		
Vireos	238	8	3	16	88	34,468
Vireos	4					
White-eyed vireo	8			1	2	10
Blue-headed vireo	19	2		2	5	
Yellow-throated vireo	3					
Warbling vireo	35	1		1	3	8,813
Red-eyed vireo	159	5	3	12	78	25,644
Cassin's vireo	3					

Wildlife Strikes to Civil Aircraft in the United States, 1990–2017

Table 18. Continued (Page 15 of 23)

Wildlife group or species	28-year totals (1990–2017)					
	Number of reported strikes				Reported economic losses ²	
	Total	With dam- age	With neg. EOF	With multiple animals ³	Aircraft down time (hrs)	Reported costs (\$)
Philadelphia vireo	7					
Japanese white-eye	3					
New World wood-warblers	1,585	14	20	113	493	434,615
N. World wood-warblers	87	1		8		1,943
Canada warbler	23		2		2	107
Yellow-breasted chat	20			1		
Pine warbler	24			2		
Black-and-white warbler	39	1		1		
Northern parula	25			3	24	2,180
Ovenbird	95	2	1	6	17	2,805
Wilson's warbler	91			3	4	5,950
Common yellowthroat	129	2	1	9	122	400,263
Yellow-rumped warbler	301	1	6	17	56	3,748
Blackpoll warbler	82		1	5	4	1,431
Mourning warbler	7					
American redstart	65	1	1	8	12	
Orange-crowned warbler	46		1	3	4	
Yellow warbler	89	2	1	10	169	
Cape May warbler	9			1		
Hooded warbler	2	1				
Prairie warbler	9					
Northern waterthrush	41	1		2	59	7,147
Nashville warbler	40		1	3		
Townsend's warbler	22		1	2		104
Louisiana waterthrush	2	1				
Palm warbler	72		2	5	3	7,476
Magnolia warbler	37		1	2	6	210
Blk-throated blue warbler	41			2		
Prothonotary warbler	3		1		4	230
MacGillivray's warbler	8					
Yellow-throated warbler	21			3		
Blk-throated gray warbler	3				2	
Blk-throated grn warbler	24			1		
Hermit warbler	5					
Tennessee warbler	44			6	2	
Chestnut-sided warbler	21			2	1	1,021
Blackburnian warbler	18			2		
Bay-breasted warbler	15			3		

Wildlife Strikes to Civil Aircraft in the United States, 1990–2017

Table 18. Continued (Page 16 of 23)

Wildlife group or species	28-year totals (1990–2017)					
	Number of reported strikes				Reported economic losses ²	
	Total	With dam- age	With neg. EOF	With multiple animals ³	Aircraft down time (hrs)	Reported costs (\$)
Connecticut warbler	3			1		
Kentucky warbler	16			2	2	
Worm-eating warbler	5	1				
Blue-winged warbler	1					
Meadowlarks	4,249	37	66	363	468	1,018,327
Meadowlarks	622	4	11	52	18	1,051
Eastern meadowlark	2,225	12	30	166	210	648,885
Western meadowlark	1,402	21	25	145	240	368,391
Blackbirds, grackles	2,571	118	137	589	1,783	1,825,189
Blackbirds	1,294	82	90	368	727	1,486,875
Red-winged blackbird	423	5	17	56	46	22,154
Yellow-headed blackbird	21	4	1	2	7	25,857
Brewer's blackbird	66	1	1	10	1	
Brown-headed cowbird	277	2	5	71	24	6,093
Bobolink	34	1	1	3	2	
Rusty blackbird	10					
Tricolored blackbird	1					
Grackles	156	12	6	32	752	210,224
Common grackle	204	8	12	40	176	73,675
Boat-tailed grackle	34	2	3	2	48	
Great-tailed grackle	51	1	1	5		310
Orioles	49	1	3	3	2	218
Orioles	6					
Baltimore oriole	26	1	2	2	2	218
Orchard oriole	5			1		
Bullock's oriole	8		1			
Hooded oriole	4					
Tanagers	76	4	1	6	90	1,241
Scarlet tanager	34	3		2	84	
Western tanager	34	1	1	2	6	1,241
Summer tanager	7			2		
Morelet's seedeater	1					
Finches	1,355	16	47	327	2,269	36,152
Finches	123	1	5	25	7	
Lapland longspur	82	1	5	30	27	
Chestnut-cld longspur	2					
Dark-eyed junco	205	3	2	8	76	11,925
Rose-breasted grosbeak	23		1	4	4	844

Wildlife Strikes to Civil Aircraft in the United States, 1990–2017

Table 18. Continued (Page 17 of 23)

Wildlife group or species	28-year totals (1990–2017)					
	Number of reported strikes				Reported economic losses ²	
	Total	With dam- age	With neg. EOF	With multiple animals ³	Aircraft down time (hrs)	Reported costs (\$)
Common chaffinch	3					
Common canary	1					
Pine siskin	23	2		9	3	
Common redpoll	4					1,034
Purple finch	6					
Red crossbill	3			1		
Evening grosbeak	1					
American goldfinch	97		2	4	3	
House finch	145	1	2	11	921	154
Smith's longspur	7			1		
Dickcissel	24	1		4		1,156
White-winged crossbill	2					
Red avadavat	7			3		
McCown's longspur	3					
Lesser goldfinch	6					
Black-headed grosbeak	11	1				
Cassin's finch	1					
Pine grosbeak	1					
Gray-crowned rosy-finch	1					
Blue grosbeak	8	1				
Hoary redpoll	2			1		
Red-crested cardinal	6			1	1	
Northern cardinal	14					
Snow bunting	337	4	26	199	107	20,197
Indigo bunting	44		3	4	1,118	843
Lazuli bunting	6					
Lark bunting	148	1		20	2	
McKay's bunting	1		1	1		
Painted bunting	7					
Black-faced bunting	1			1		
Sparrows	5,541	83	147	911	1,513	1,107,876
Sparrows	3,452	52	124	783	703	78,763
Harris's sparrow	8			1		
Swamp sparrow	96	1		5	245	4,609
Savannah sparrow	675	7	8	39	32	21,319
Fox sparrow	66	3	3	4	25	60,855
White-throated sparrow	274	5	3	26	56	21,425
Golden-crowned sparrow	21			1	6	153

Wildlife Strikes to Civil Aircraft in the United States, 1990–2017

Table 18. Continued (Page 18 of 23)

Wildlife group or species	28-year totals (1990–2017)					
	Number of reported strikes				Reported economic losses ²	
	Total	With dam- age	With neg. EOF	With multiple animals ³	Aircraft down time (hrs)	Reported costs (\$)
Field sparrow	63			5	1	
Lark sparrow	29	1	1	2		15,530
White-crowned sparrow	108	6	3	6	408	792,726
Grasshopper sparrow	103	2	1	4	9	33,947
Java sparrow	3			1		
Vesper sparrow	57	1		5		
Chipping sparrow	101	1		7	2	107
Lincoln's sparrow	99	2	3	2	4	16,832
Song sparrow	298	2		17	20	61,122
Bell's sparrow	7				1	
American tree sparrow	32			2		263
Nelson's sparrow	6				1	225
Black-throated sparrow	3					
Brewer's sparrow	19		1	1		
LeConte's sparrow	6					
Cassin's sparrow	3					
Clay-colored sparrow	11					
Baird's sparrow	1					
Towhees	46	1		1	9	15,032
Eastern towhee	31	1		1	9	15,032
Green-tailed towhee	7					
California towhee	2					
Spotted towhee	6					
Waxbills, mannikins	291	1	3	81	22	10,116
Waxbills, mannikins	3					
Common waxbill	8		1	2		
Munias	122			13		
Scaly-breasted munia	92		1	37	19	6,992
Chestnut munia	61	1	1	25	3	3,124
White-throated munia	5			4		
House sparrow	300	4	3	30	33	15,530
Total known birds	104,015	7,750	6,182	16,343	498,490	563,926,505
Total unknown birds	87,157	6,995	4,743	8,382	209,601	134,508,527
Unknown bird-?size	10,839	638	616	566	12,947	4,940,779
Unknown bird - large	3,055	1,141	561	311	51,038	52,619,274
Unknown bird - medium	35,761	4,164	2,187	2,806	104,512	57,214,278
Unknown bird - small	37,502	1,052	1,379	4,699	41,104	19,734,196
Total birds	191,172	14,745	10,925	24,725	708,090	698,435,032

Wildlife Strikes to Civil Aircraft in the United States, 1990–2017

Table 18. Continued (Page 19 of 23)

Wildlife group or species	28-year totals (1990–2017)					
	Number of reported strikes				Reported economic losses ²	
	Total	With dam- age	With neg. EOF	With multiple animals ³	Aircraft down time (hrs)	Reported costs (\$)
Flying mammals (Bats)						
Bats (mega or micro)	3	1		2		9,731
Megabats (fruit bats)	14	2	2	4	99	4,485,974
Megabats (unk species)	12	2	2	4	99	4,485,974
Flying fox	1					
Little red flying fox	1					
Microbats (echo locating)	2,226	14	10	152	186	573,235
Microbats (unk species)	954	6	6	81	70	3,280
Vesper bats	91			1	1	1,350
Eastern red bat	187	3		11	51	13,786
Hoary bat	103	3		3	23	207,132
East. small-footed myotis	1					
Little brown bat	157			7		
Big brown bat	109		2	9		
Silver-haired bat	65			4	3	941
Seminole bat	10					
Eastern pipistrelle	20					
Northern yellow bat	6			1		
Evening bat	17					
Indiana bat	2					
Yuma myotis	1					
Long-eared myotis	1					
Western yellow bat	1					
Common pipistrelle	2					
Long-legged myotis	1					
West. small footed myotis	1					
Free-tailed bats	196			16	12	597
Brazilian free-tailed bat	287	1	2	17	6	1,149
Pocketed free-tailed bat	2					
Big free-tailed bat	1					
Western mastiff bat	4	1			20	345,000
Florida bonneted bat	1					
Pallas's mastiff bat	2			1		
Gray sac-winged bat	1					
Jamaican fruit bat	3			1		
Total known bats	2,240	16	12	156	285	5,059,209
Total unk-Mega or Micro	3	1		2		9,731
Total bats	2,243	17	12	158	285	5,068,940

Wildlife Strikes to Civil Aircraft in the United States, 1990–2017

Table 18. Continued (Page 20 of 23)

Wildlife group or species	28-year totals (1990–2017)					
	Number of reported strikes				Reported economic losses ²	
	Total	With dam- age	With neg. EOF	With multiple animals ³	Aircraft down time (hrs)	Reported costs (\$)
Terrestrial mammals						
Marsupials (V. opossum)	265	1		3		
Xenarthras (armadillo)	39	1	4		11	1,296
Lagomorphs	654	9	12	8	21	129,054
Lagomorphs	1	1				
Hares	7		1		1	
Black-tailed jackrabbit	359	5	4	1	12	34,284
White-tailed jackrabbit	50		1	2	1	
Antelope jackrabbit	1					
Rabbits	92		2	5	1	
Eastern cottontail	108	3	4		6	94,770
Desert cottontail	36					
Rodents	306	2	9	5	6	500
North American beaver	3					
Prairie dogs	1					
Black-tailed prairie dog	57		1	2		
White-tailed prairie dog	5					
Gunnison's prairie dog	17		1	3		
Woodchuck	162	2	7		6	500
Yellow-bellied marmot	1					
Squirrels	7					
Fox squirrel	1					
Muskrat	34					
N. American porcupine	17					
Coypu (nutria)	1					
Carnivores	1,566	84	174	22	19,819	4,386,172
Canids	4	1	1			
Coyote	575	51	111	6	16,718	3,869,840
Domestic dog	49	16	25	1	559	396,846
Foxes	70	4	7	1	10	1,067
Red fox	187	4	18		364	59,436
Common gray fox	10	2	2		5	532
Kit fox	4					
Raccoon	136	4	4	6	2,160	58,451
White-nosed coati	1					
Skunks	62		1	2	2	
Striped skunk	410	1	2	6	1	
River otter	2	1				

Wildlife Strikes to Civil Aircraft in the United States, 1990–2017

Table 18. Continued (Page 21 of 23)

Wildlife group or species	28-year totals (1990–2017)					
	Number of reported strikes				Reported economic losses ²	
	Total	With damage	With neg. EOF	With multiple animals ³	Aircraft down time (hrs)	Reported costs (\$)
Badger	7					
Mink	6					
Domestic cat	37					
Small Indian mongoose	3					
American black bear	2		2			
Bearded sea lion	1		1			
Artiodactyls	1,202	1,005	555	94	303,370	57,130,775
Deer	18	16	9		2,136	285,736
White-tailed deer	1,060	879	483	83	250,632	47,005,836
Mule deer	80	71	37	3	21,409	1,467,064
Wapiti (elk)	11	11	5	1	11,660	7,572,312
Moose	5	4	4			
Caribou	3	2	2			
Cattle	11	11	8	4	9,215	500,579
Domestic sheep	1	1	1			
Pronghorn	8	7	5	2	5,130	240,643
Swine (pigs)	3	2			3,188	58,606
Collared peccary	2	1	1	1		
Perissodactyls	5	5	4		1,008	36,417
Horse	4	4	4		1,008	36,417
Burro	1	1				
Total known t. mammals	4,037	1,107	758	132	324,235	61,684,214
Unkn terrestrial mammals	29	9	9	1		
Total t. mammals	4,066	1,116	767	133	324,235	61,684,214
Reptiles						
Turtles	276	1	5	2		
Turtles	96		3			
Florida soft shell turtle	11	1	1			
Pond slider	4					
Eastern mud turtle	1					
Chicken turtle	1					
Striped mud turtle	1					
Eastern box turtle	16					
Common snapping turtle	32		1			
Diamondback terrapin	50			2		
Painted turtle	31					
Florida red-bellied cooter	3					

Table 18. Continued (Page 22 of 23)

Wildlife group or species	28-year totals (1990–2017)					
	Number of reported strikes				Reported economic losses ²	
	Total	With damage	With neg. EOF	With multiple animals ³	Aircraft down time (hrs)	Reported costs (\$)
Gopher tortoise	26					
Alligator snapping turtle	1					
Coastal plain cooter	3					
American alligator	23	2	2		3	
Green iguana	18		4			
Snakes	36					
Snakes	16					
Gopher snake	12					
Northern water snake	3					
E. diamondback rattlesnake	3					
Water moccasin	1					
Eastern pine snake	1					
Total reptiles	353	3	11	2	3	
Total known (all species)	110,645	8,876	6,963	16,633	823,013	630,669,929
Total (unknown species)	87,189	7,005	4,752	8,385	209,601	134,518,258
Grand total	197,834	15,881	11,715	25,018	1,032,613	765,188,186

¹ Includes strikes to U.S.-registered aircraft in foreign countries.

² These reported economic losses by species and species groups should be considered as relative indices of losses and not as actual estimated losses. For commercial aviation, an estimated 20 percent of strikes were reported in the 1990s. More recent analyses estimated that strike reporting for all civil aircraft combined (commercial and general aviation) at Part 139 airports had improved to 39 percent in 2004-2008 and to 47 percent in 2009-2013 (Dolbeer 2009, 2015). Strike reporting for commercial aircraft only at Part 139 airports was an estimated 79 percent in 2004-2008 and 91 percent in 2009-2013; reporting of strikes with damage was estimated at 78 percent and 93 percent for these respective time periods. In addition, only about 56 percent of reported strikes identified the wildlife species or species group responsible, 1990–2017. Furthermore, of the 15,880 reports indicating damage to the aircraft, only 27 percent (4,330) also provided an estimate of repair costs, and only 37 percent (10,126) of the 27,258 strikes indicating an adverse effect estimated the downtime (see Tables 23, 24). Finally, even when cost estimates were provided, some reports were filed before aircraft damage had been fully assessed. See Tables 23 and 24 for a more detailed projection of actual economic losses.

³ More than 1 animal was struck by the aircraft.

⁴ Of the 191,172 reported bird strikes, 82,935 (43 percent) identified the bird to exact species (a total of 550 species of birds of which 279 caused damage) and an additional 21,077 strikes (11 percent) identified the bird at least to species group (e.g., gull, hawk, duck). Exact species identification has improved from less than 20 percent in the early 1990s to 61 percent in 2017 (Figure 7).

Table 18. Continued (Page 23 of 23)

⁵ Of the 2,243 reported bat strikes, 986 (44 percent) identified the bat to exact species (26 species total of which 4 caused damage) and 1,254 (56 percent) identified the bat to species group (13 megabats [old world fruit bats] and 1,241 microbats [echo-locating bats]) of which 954 were microbats of unknown species, 196 were free-tailed bats and 91 were vesper bats. There were 3 bat strikes classified as unknown bat (either megabat or microbat).

⁶ Of the 4,066 reported terrestrial mammal strikes, 3,775 (93 percent) identified the mammal to exact species (a total of 44 species of which 24 caused damage) and 262 (6 percent) identified the mammal at least to species group.

⁷ All of the 353 reported reptile strikes were identified to species group and 261 (74 percent) were identified to exact species (20 species total of which 2 caused damage).

⁸ Reported costs of \$765,188,186 include \$677,424,648 in direct repair costs and \$87,763,538 in other costs.

Table 19. Number of reported strikes, strikes with damage, and strikes involving multiple animals for the five most commonly struck bird groups and three most commonly struck terrestrial mammal groups, civil aircraft, USA¹, 1990–2017.

Species group ²	Reported strikes		Strikes with damage		Strikes with >1 animal	
	28-year total	% of total known	28-year total	% of total known	28-year total	% of total known
<u>Birds</u>						
Pigeons, doves	14,253	14	535	7	2,565	16
Raptors	13,152	13	1,686	22	497	3
Gulls	11,472	11	1,514	20	2,286	14
Shorebirds	9,165	9	172	2	1,260	8
Waterfowl	5,523	5	2,199	28	1,875	11
All other known	50,450	49	1,644	50	7,860	40
Total known bird	104,015	100	7,750	100	16,343	100
Unknown birds	87,157		6,995		8,382	
Total birds	191,172		14,745		24,725	
<u>Terrestrial mammals</u>						
Artiodactyls	1,202	30	1,005	91	94	71
Carnivores	1,566	39	84	8	22	17
Lagomorphs	654	16	9	1	8	6
All other known	615	15	9	1	8	6
Known t. mammals	4,037	100	1,107	100	132	100
Unknown t. mammals	29		9		1	
Total t. mammals	4,066		1,116		133	

¹ Includes strikes to U.S.-registered aircraft in foreign countries.

² See Table 18 for listing of species within each species group and Table 20 for the most frequently struck species.

³ Hawks, eagles, vultures, falcons, and caracaras.

Table 20. The 30 species of birds identified most frequently as struck by civil aircraft in USA, 1990–2017 and 2017 only. See Figure 15 for relation between mean body mass of species and percent of strikes causing damage.

Rank	Bird species	Strikes (1990–2017) ¹		Bird species	Strikes (2017 only) ¹	
		Num- ber	% causing damage		Num- ber	% causing damage
1	Mourning dove	9,157	2.2	Mourning dove	816	2.0
2	Killdeer	5,720	1.0	Barn swallow	671	0.9
3	American kestrel	5,622	0.6	Killdeer	645	0.0
4	Barn swallow	5,293	0.5	American kestrel	578	0.9
5	Horned lark	4,636	0.5	Horned lark	510	0.2
6	European starling	4,529	3.0	European starling	333	0.9
7	Rock pigeon	3,202	8.0	Eastern meadowlark	292	0.7
8	Red-tailed hawk	2,693	13.6	Red-tailed hawk	226	7.5
9	Eastern meadowlark	2,225	0.5	Cliff swallow	211	0.5
10	Cliff swallow	1,750	0.3	American robin	168	7.1
11	Ring-billed gull	1,718	7.6	Rock pigeon	151	2.0
12	Canada goose	1,716	49.2	Western meadowlark	146	0.0
13	Western meadowlark	1,402	1.5	Chimney swift	141	0.7
14	Herring gull	1,357	9.3	Song sparrow	140	1.4
15	Barn owl	1,339	3.6	Barn owl	118	3.4
16	American robin	1,279	7.4	Savannah sparrow	96	2.1
17	Pacific golden-plover	1,073	1.2	Ring-billed gull	89	6.7
18	Mallard	1,003	21.0	Common nighthawk	89	1.1
19	Tree swallow	793	0.0	Tree swallow	84	0.0
20	Chimney swift	786	1.0	Canada goose	72	48.6
21	Turkey vulture	755	50.5	Mallard	68	8.8
22	Common nighthawk	690	0.6	Turkey vulture	67	35.8
23	Savannah sparrow	675	1.0	Swainson's thrush	64	6.3
24	Short-eared owl	566	2.3	Yellow-rumped warbler	64	1.6
25	Laughing gull	519	4.0	Herring gull	62	6.5
26	Bank swallow	507	0.4	Short-eared owl	62	3.2
27	American crow	492	7.1	Cedar waxwing	59	0.0
28	Cattle egret	481	8.1	Pacific golden-plover	54	1.9
29	Great blue heron	430	19.5	Cattle egret	47	8.5
30	Red-winged blackbird	423	1.2	Red-winged blackbird	45	0.0

¹ Actual number struck was higher for each species because only 43 percent and 61 percent of the bird strike reports from 1990–2017 and in 2017, respectively, identified the bird to species. For example, there were 6,921 gull strikes reported from 1990–2017 in which the species of gull was not determined (Table 18).

Table 21. Number of strikes to civil aircraft causing human fatality or injury and number of injuries and fatalities by wildlife species, USA¹, 1990–2017.

Species of wildlife	No. of strikes	No. of humans		Species of wildlife	No. of strikes	No. of humans
<u>Strikes causing fatalities</u>				<u>Strikes causing injuries (continued)</u>		
Unknown bird	6	8		Osprey	3	3
Red-tailed hawk	1	8		Herring gull	3	3
Amer. white pelican	1	5		Rock pigeon	3	3
Bald eagle	1	4		Cattle	2	3
Snow goose	1	3		Western grebe	2	3
Canada goose	1	2		Gr. white-fronted goose	2	3
White-tailed deer	1	1		Domestic dog	1	2
Brown pelican	1	1		Mule deer	1	2
Turkey vulture	1	1		Red-throated loon	1	2
Total fatalities	14	33		Sharp-tailed grouse	1	2
<u>Strikes causing injuries</u>				Eastern cottontail	1	1
Unknown bird	46	61		Horse	1	1
White-tailed deer	20	28		Horned grebe	1	1
Turkey vulture	17	21		White-tailed Tropicbird	1	1
Ducks	17	20		Red-tailed tropicbird	1	1
Canada goose	15	18		Great frigatebird	1	1
Black vulture	9	14		Magnificent frigatebird	1	1
Red-tailed hawk	8	10		Egrets	1	1
New World Vultures	9	9		Snowy egret	1	1
Gulls	8	9		White ibis	1	1
Ring-billed gull	3	9		Long-tailed duck	1	1
Mallard	6	7		Cackling goose	1	1
Bald eagle	4	7		Wedge-tailed eagle	1	1
Geese	6	6		Sandhill crane	1	1
Snow goose	5	5		Franklin's gull	1	1
American coot	5	5		Doves	1	1
D.-c. cormorant	4	5		Mourning dove	1	1
Hawks	3	5		Owls	1	1
American kestrel	1	5		American robin	1	1
Lesser scaup	4	4		Veery	1	1
Anhinga	3	4		Baltimore oriole	1	1
Golden eagle	2	4		Great-tailed grackle	1	1
Eurasian kestrel	1	4		Sparrows	1	1
Spotted dove	1	4		Total injuries	239	313

¹ Includes strikes to U.S.-registered aircraft in foreign countries.

Table 22. Number of civil aircraft lost (destroyed or damaged beyond repair) after striking wildlife by wildlife species and aircraft mass category, USA¹, 1990–2017. See Figure 16 for number of lost aircraft by year, 1990–2017.

Wildlife species or species group	Aircraft ² mass category (Maximum take-off mass in kilograms)				Total aircraft lost
	≤2,250	2,251-5,700	5,701-27,000	>27,000	
White-tailed deer	15	6	2		23
Unknown bird	12	2	1		15
Canada goose	1	3		1	5
Bald eagle	3				3
Cattle	2	1			3
Turkey vulture	3				3
Hawks	2				2
American white pelican		1			1
Brown pelican	1				1
Coyote			1		1
Domestic dog	1				1
D.-c. cormorant	1				1
Ducks	1				1
Eastern cottontail	1				1
Eurasian kestrel				1	1
Herring gull		1			1
Mourning dove			1		1
Mule deer	1				1
New World Vultures	1				1
Red-tailed hawk		1			1
Ring-billed gull		1			1
Snow goose		1			1
Wapiti (elk)			1		1
Total	45	17	6	2	70

¹ Includes strikes to U.S.-registered aircraft in foreign countries.

² Engine types on the 68 destroyed aircraft were piston (50), turbofan (8), turboprop (5), turbojet (3), and turboshaft (4). Aircraft operators were business (39), private (25), commercial transport (5), and government (1).

³ Forty-one (59 percent) of the 70 wildlife strikes resulting in a destroyed aircraft occurred at general aviation airports, 17 occurred “en route”, 7 occurred at USA airports certificated for passenger service under 14 CFR Part 139, 3 occurred in miscellaneous situations (taking off from river, herding cattle, aerial application of pesticides) and 2 occurred at foreign airports.

Table 23. Number of reported wildlife strikes indicating damage, a negative effect-on-flight (EOF), aircraft downtime, repair costs, and other costs; and the mean losses per report in hours of downtime and inflation-adjusted U.S. dollars, civil aircraft, USA¹, 1990–2017.

Year	Number of reports indicating:					Mean losses per report ²		
	Dam- age	Neg. EOF	Aircraft down time	Repair costs	Other costs	Down- time (hours)	Repair costs (\$)	Other costs (\$)
1990	372	148	60	33	16	56.4	216,055	62,021
1991	400	184	61	49	25	79.8	73,301	39,513
1992	365	218	81	51	28	111.9	104,859	5,276
1993	399	240	67	57	19	277.9	89,064	9,401
1994	460	272	103	73	29	388.4	76,686	91,574
1995	497	307	95	62	33	96.3	504,569	220,274
1996	502	355	144	86	39	137.3	84,553	25,302
1997	578	379	182	126	47	230.7	76,242	39,909
1998	584	400	205	135	54	119.5	200,851	28,637
1999	703	445	282	179	79	148.8	110,584	20,948
2000	762	477	351	205	93	195.2	98,263	114,422
2001	645	434	293	157	65	142.6	284,408	39,010
2002	672	499	383	166	63	135.6	151,311	64,159
2003	632	438	355	172	81	111.8	161,363	42,731
2004	626	429	325	213	92	166.3	105,194	22,708
2005	605	452	328	227	125	87.7	267,308	77,006
2006	597	429	333	172	102	116.8	214,453	13,336
2007	569	454	364	178	135	165.2	172,553	33,219
2008	525	408	371	156	141	116.2	117,910	14,006
2009	605	519	563	195	193	80.8	374,456	14,668
2010	597	468	528	174	165	66.3	130,076	13,740
2011	542	499	526	179	208	70.8	234,803	15,127
2012	612	540	689	228	263	75.4	110,202	8,453
2013	609	521	802	244	302	75.7	63,789	12,554
2014	584	573	717	218	273	63.2	134,500	10,813
2015	619	543	705	210	292	48.0	148,213	19,516
2016	589	529	587	170	212	87.4	66,497	14,728
2017	630	557	626	215	237	50.4	87,162	13,596
Total	15,880	11,717	10,126	4,330	3,411			
Mean	567	418	362	155	122	102.0	156,449	25,730

¹ Includes strikes to U.S.-registered aircraft in foreign countries.² See Table 18 for actual losses reported in total and by species of wildlife, 1990-2017.

Wildlife Strikes to Civil Aircraft in the United States, 1990–2017

Table 24. Minimum projected annual losses in aircraft downtime (hours) and in repair and other costs (inflation-adjusted U.S. dollars) from wildlife strikes with civil aircraft, USA¹, 1990–2017. Losses are projected from mean reported losses per incident (Table 23). (Page 1 of 2).

Year	No. of adverse incidents ⁴	Minimum projected losses ^{2, 3}			
		Down-time (hours)	Repair costs (x \$1 million)	Other costs (x \$1 million)	Total costs (x \$1 million)
1990	427	24,061	92	26	119
1991	484	38,601	35	19	55
1992	493	55,179	52	3	54
1993	509	141,456	45	5	50
1994	582	226,070	45	53	98
1995	656	63,149	331	145	476
1996	684	93,891	58	17	75
1997	783	180,606	60	31	91
1998	806	96,319	162	23	185
1999	979	145,649	108	21	129
2000	1,112	217,046	109	127	237
2001	977	139,314	278	38	316
2002	1,105	149,841	167	71	238
2003	998	111,602	161	43	204
2004	950	158,029	100	22	122
2005	975	85,550	261	75	336
2006	941	109,910	202	13	214
2007	979	161,772	169	33	201
2008	905	105,126	107	13	119
2009	1,186	95,857	444	17	462
2010	1,129	74,843	147	16	162
2011	1,146	81,107	269	17	286
2012	1,333	100,567	147	11	158
2013	1,447	109,550	92	18	110
2014	1,458	92,205	196	16	212
2015	1,453	69,683	215	28	244
2016	1,347	117,701	90	20	109
2017	1,414	71,253	123	19	142
Total	27,258	3,115,939	4,265	939	5,204
Mean	974	111,284	152	34	186

Table 24. Continued (Page 2 of 2).

¹ Includes strikes to U.S.-registered aircraft in foreign countries.

² Minimum values are based on the assumption that all 27,258 reported strikes (mean of 974/year) indicating an adverse effect (see footnote 3) incurred similar amounts of damage and/or downtime and that these reports are all of the adverse-effect strikes that occurred, 1990–2017.

³ Analyses of strike data from 1991-2004 indicated that 11 to 21 percent of strikes were reported for air carrier aircraft at Part 139 airports certificated for passenger traffic (Linnell et al. 1999, Cleary et al. 2005, Wright and Dolbeer 2005). Strike reporting for general aviation (GA) aircraft at GA airports was estimated at less than 5 percent in the 1990s and early 2000s (Dolbeer et al. 2008, Dolbeer 2009). More recent analyses estimated that strike reporting for all civil aircraft combined (commercial and general aviation) at Part 139 airports had improved to 39 percent in 2004-2008 and to 47 percent in 2009-2013 (Dolbeer 2009, 2015). Strike reporting for commercial aircraft only at Part 139 airports was an estimated 79 percent in 2004-2008 and 91 percent in 2009-2013; reporting of strikes with damage was estimated at 78 percent and 93 percent for these respective time periods. For these reasons, we project that actual costs are likely 2 or more times higher than these minimum estimates.

⁴ Number of reports indicating one or more of the following: damage, negative effect on flight (EOF), downtime, repair costs, other costs.

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Figures

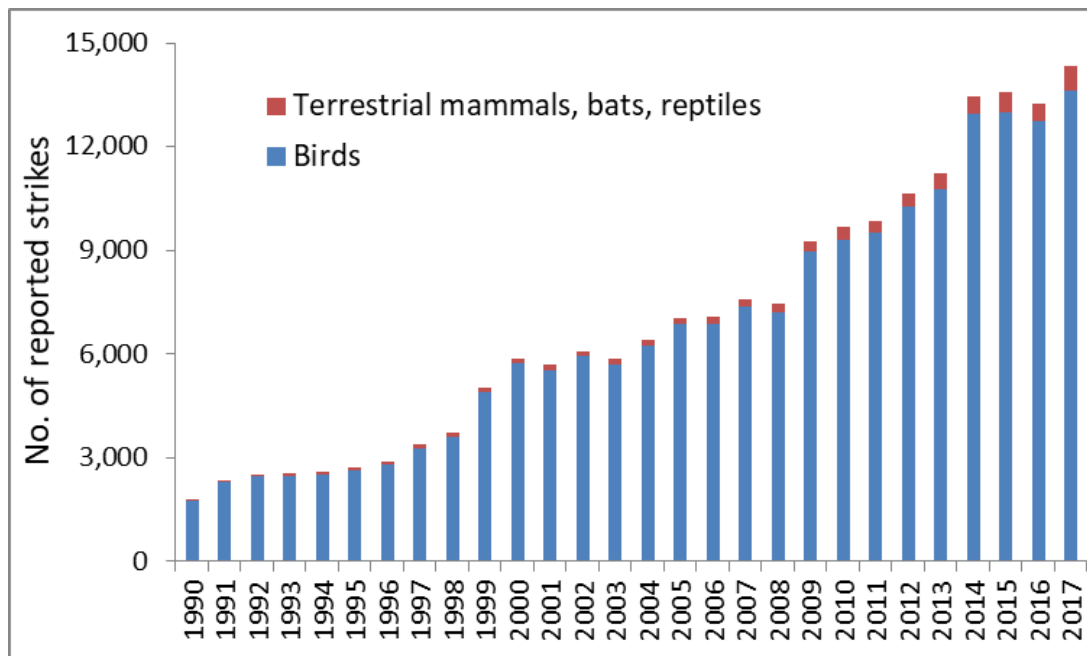


Figure 1. Number of reported wildlife strikes with civil aircraft, USA, 1990–2017. The 193,969 strikes involved birds (187,343), terrestrial mammals (4,054), bats (2,219), and reptiles (353). An additional 3,864 strikes were reported for U.S.-registered aircraft in foreign countries (see Tables 1 and 18).

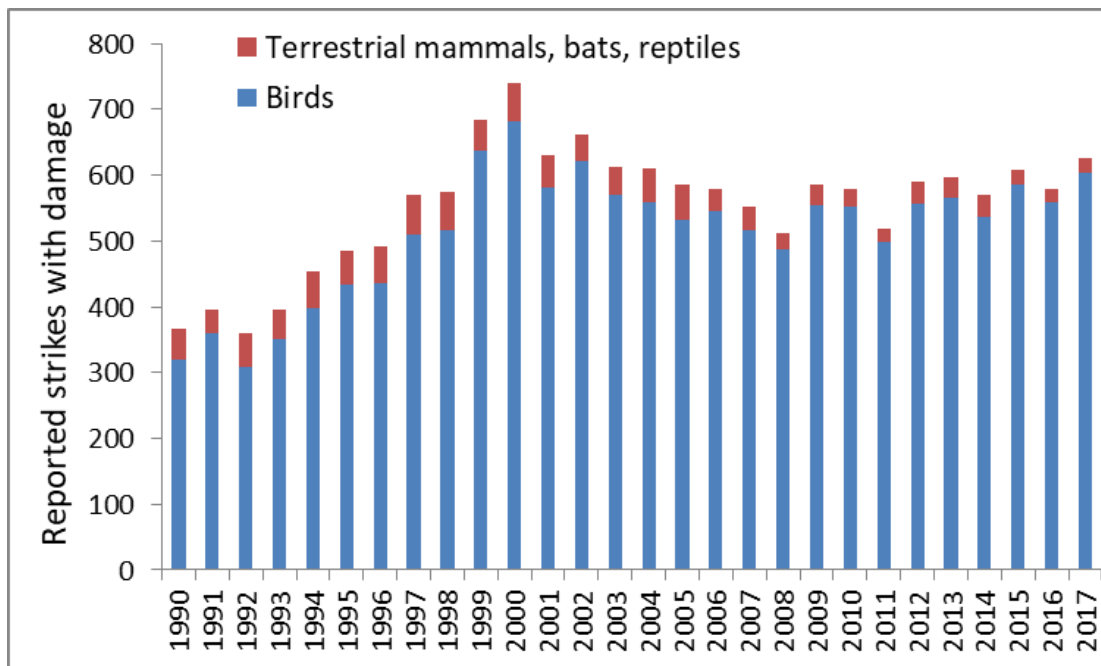


Figure 2. Number of reported wildlife strikes causing damage to civil aircraft, USA, 1990–2017. The 15,506 damaging strikes involved birds (14,374), terrestrial mammals (1,115), bats (14), and reptiles (3). An additional 377 damage strikes were reported for U.S.-registered aircraft in foreign countries (see Tables 1 and 18).

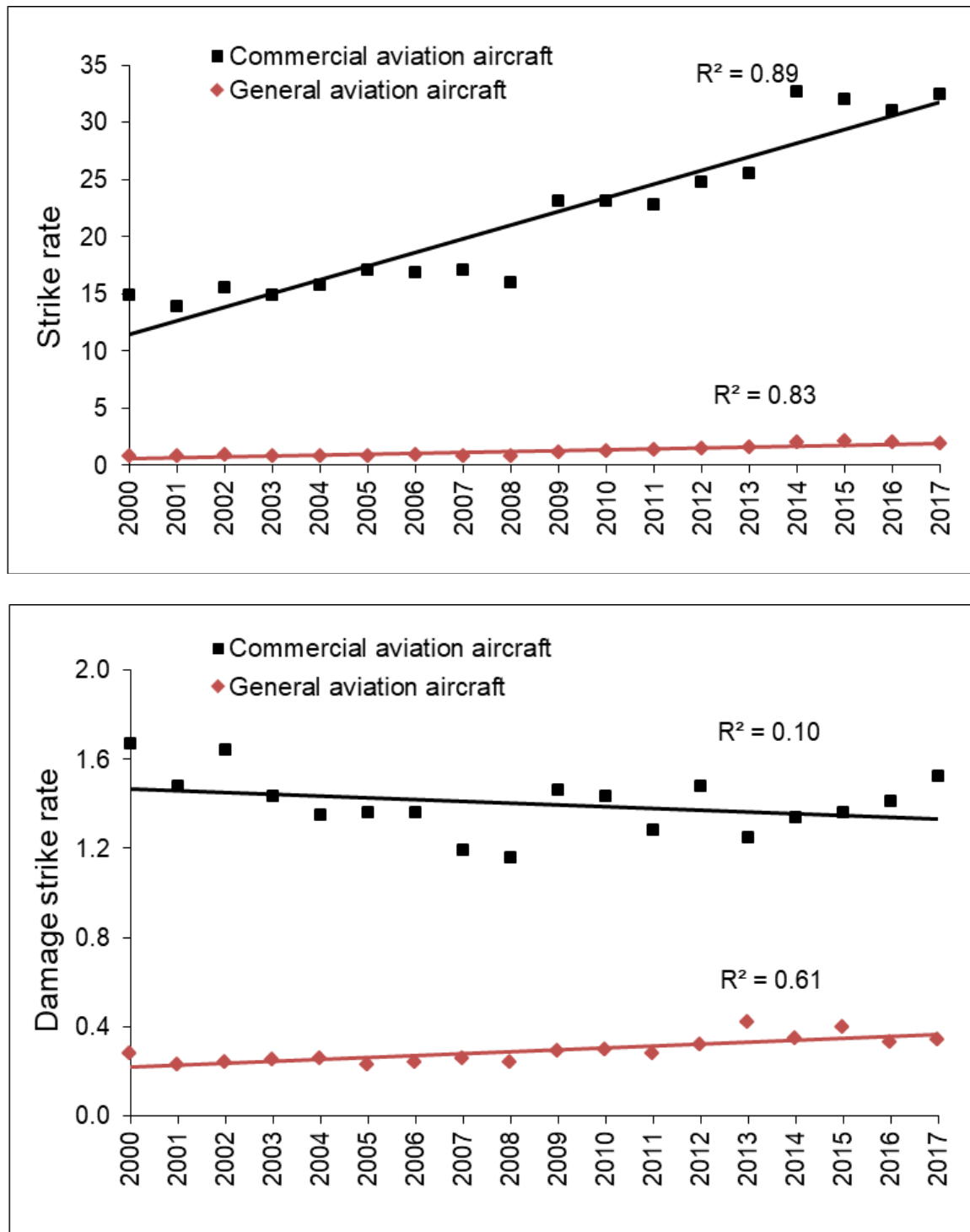


Figure 3. The strike rate and damaging strike rate (number of reported strikes and damaging strikes per 100,000 aircraft movements) for commercial (air carrier, commuter, and air taxi service) and general aviation aircraft, USA, 2000–2017. Strikes involving U.S.-registered aircraft in foreign countries are excluded. R^2 values greater than 0.22 and 0.35 indicate significant trends at the 0.05 and 0.01 levels of probability, respectively (Steel and Torrie 1960; see Tables 3 and 4 for complete data, 1990–2017).

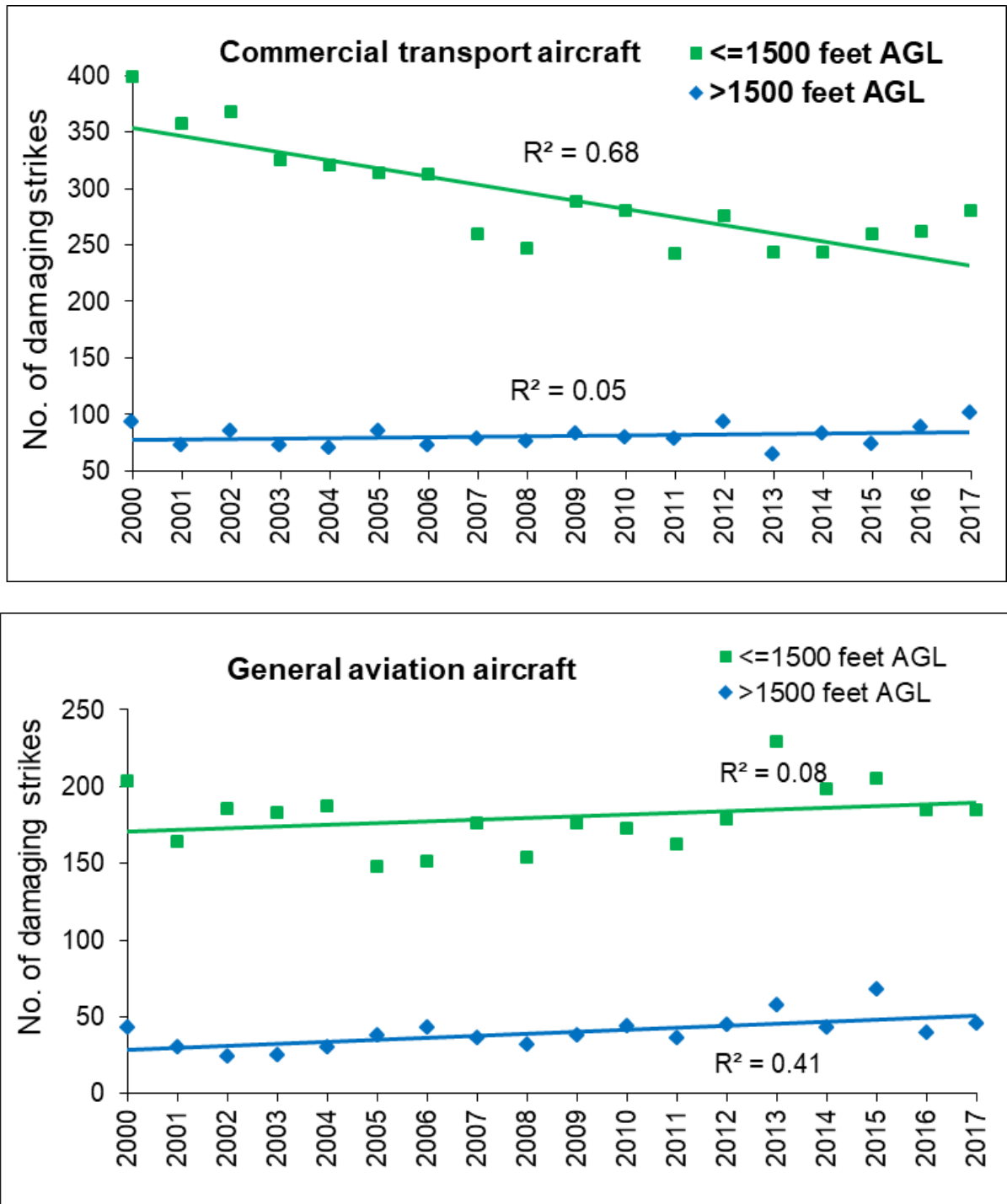


Figure 4. Number of damaging strikes with commercial (top graph) and general aviation (bottom graph) aircraft occurring at \leq and >1500 feet above ground level (AGL) for all wildlife species, USA, 2000–2017. Strikes with unknown height AGL are included with strikes at ≤ 1500 feet AGL. Strikes involving U.S.-registered aircraft in foreign countries are excluded. R^2 values greater than 0.22 and 0.35 indicate significant trends at the 0.05 and 0.01 levels of probability, respectively (Steel and Torrie 1960).

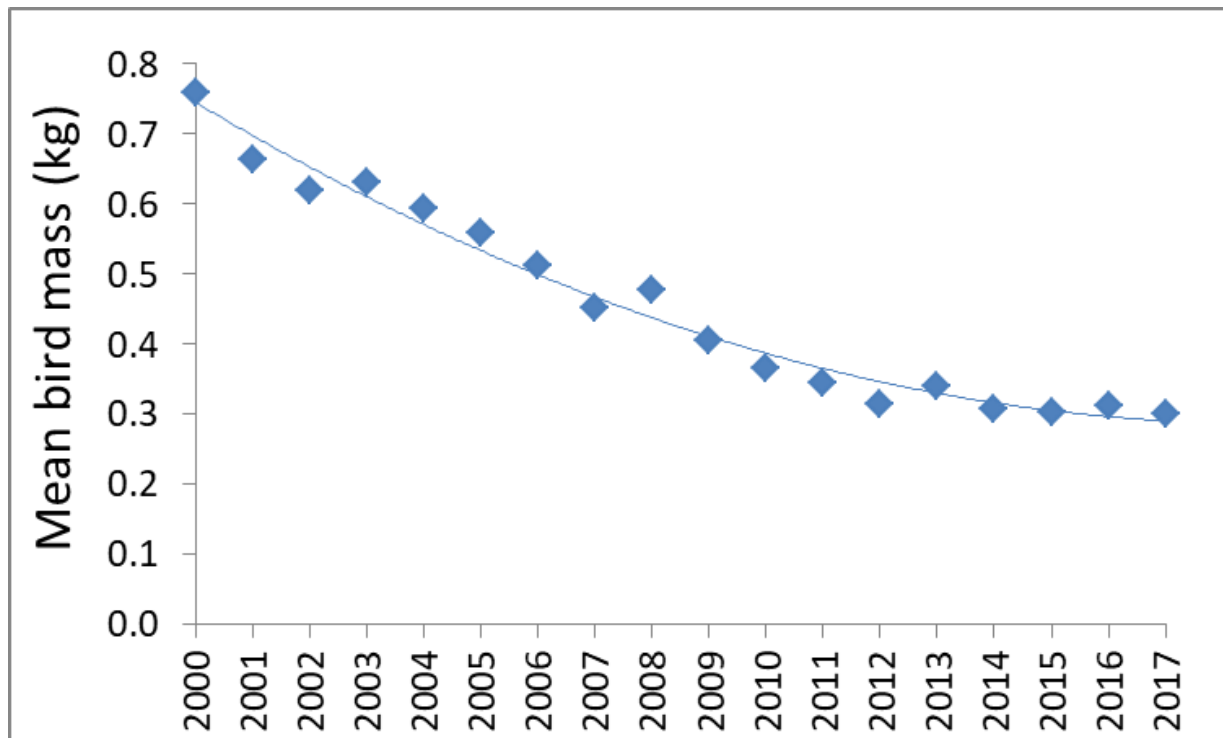


Figure 5. The mean body mass of birds reported as struck by civil aircraft in USA has declined by 60 percent from 2000 to 2017. This indicates that airports, pilots, and commercial aviation in general, are doing a better job of documenting all wildlife that are struck, many of which are small species that rarely cause damage. Means were calculated from all strikes in which the bird was identified to species. See Figure 14 for number of identified bird species struck each year.

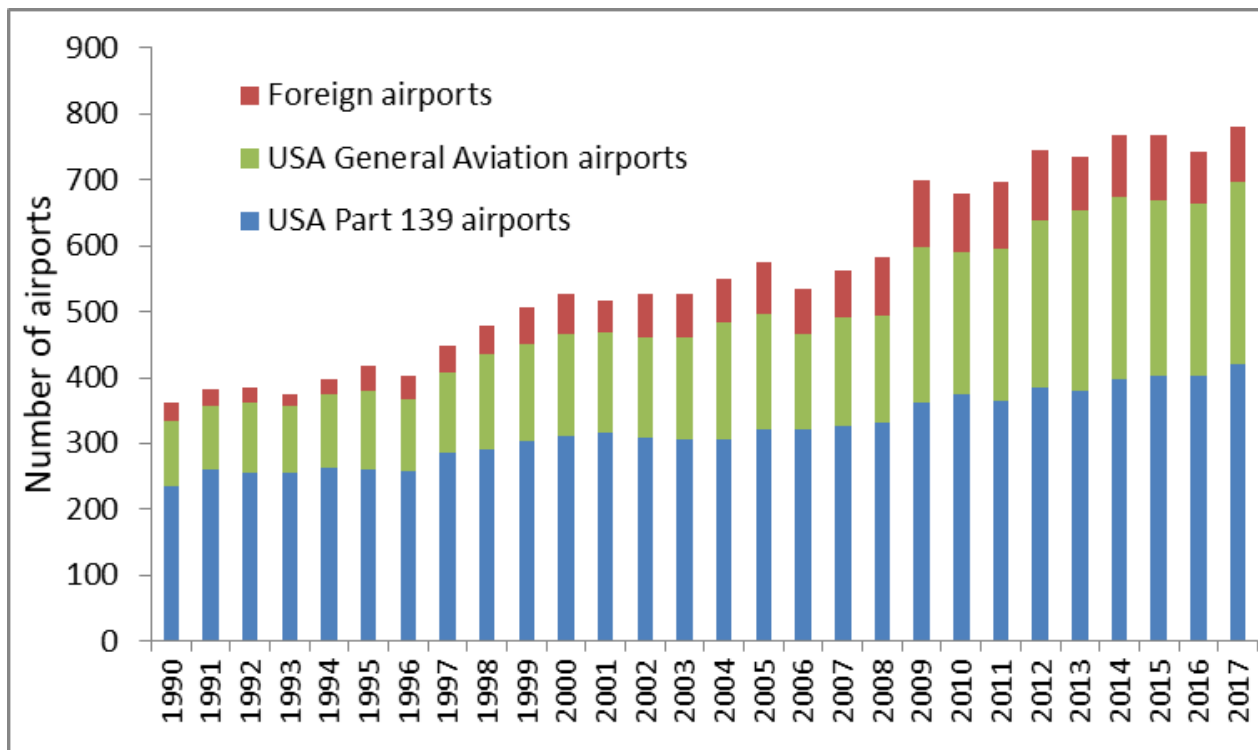


Figure 6. Number of Part 139-certificated airports and general aviation (GA) airports in USA with reported wildlife strikes and number of foreign airports at which strikes were reported for U.S.-registered civil aircraft, 1990–2017. Strikes were reported from 2,009 USA airports (520 Part 139-certificated, 1,489 GA) and 308 foreign airports in 109 countries, 1990-2017 (Table 8).

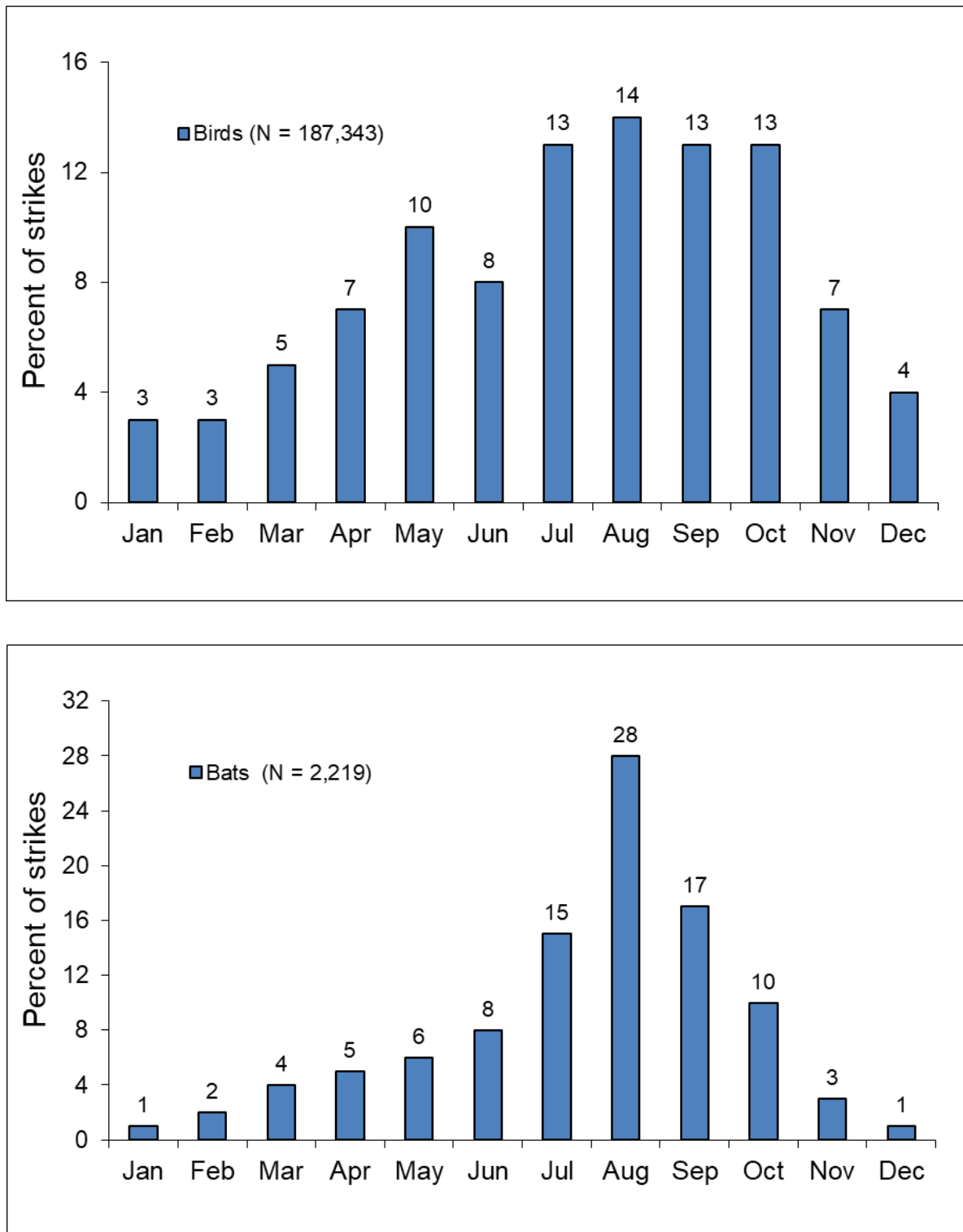


Figure 7. Percentage of reported bird (top graph) and bat (bottom graph) strikes with civil aircraft by month, USA, 1990–2017. Bird (3,828) and bat (24) strikes reported for U.S.-registered aircraft in foreign countries were excluded.

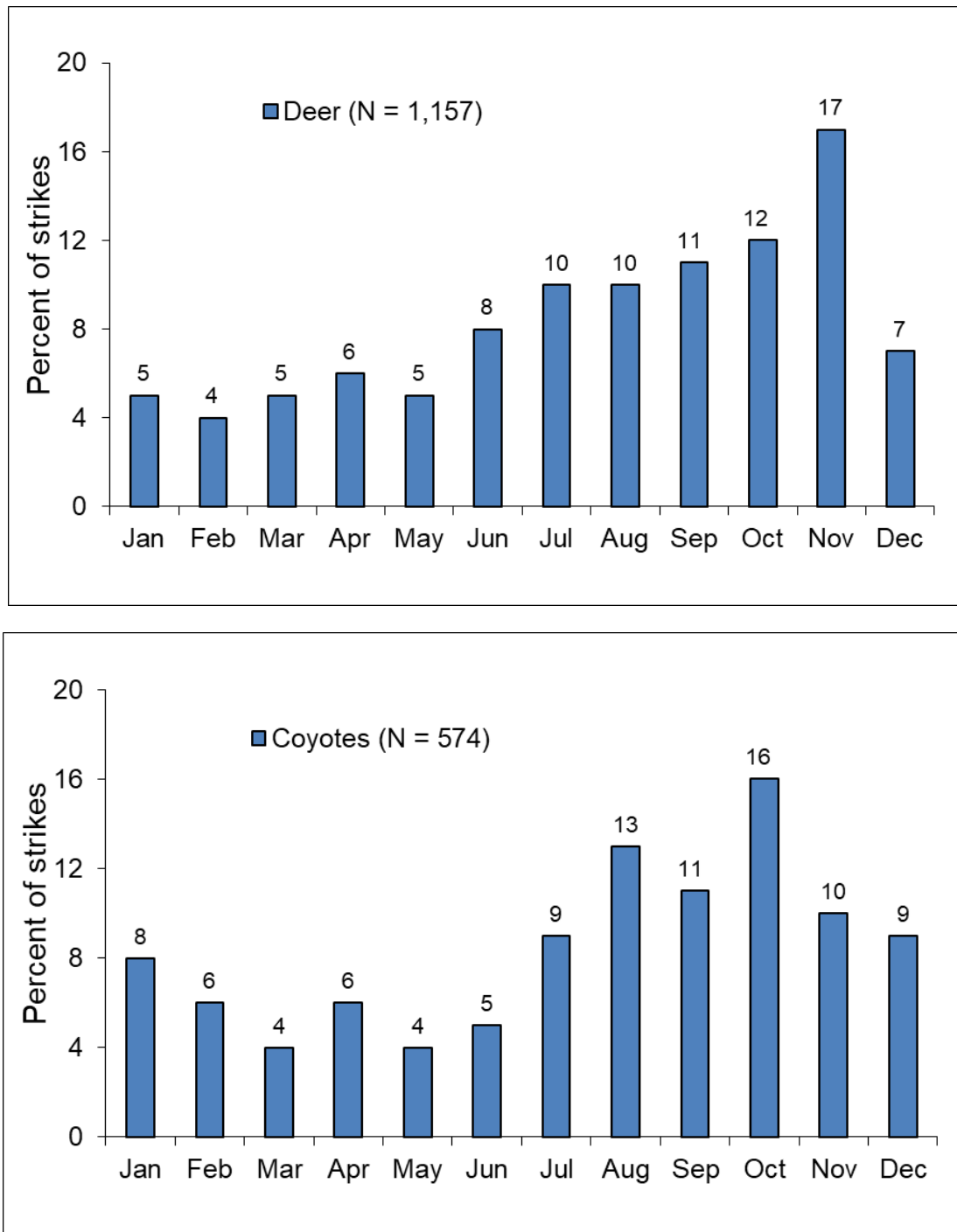


Figure 8. Percentage of reported deer (top graph) and coyote (bottom graph) strikes with civil aircraft by month, USA, 1990–2017. One deer and 1 coyote strike reported for U.S.-registered aircraft in foreign countries were excluded. Deer (1,060 white-tailed, 80 mule, 18 unidentified to species) and coyotes are the most commonly struck terrestrial mammals (Table 18). Biondi et al. (2011) provide a more detailed analysis of deer strikes with civil aircraft in the USA.

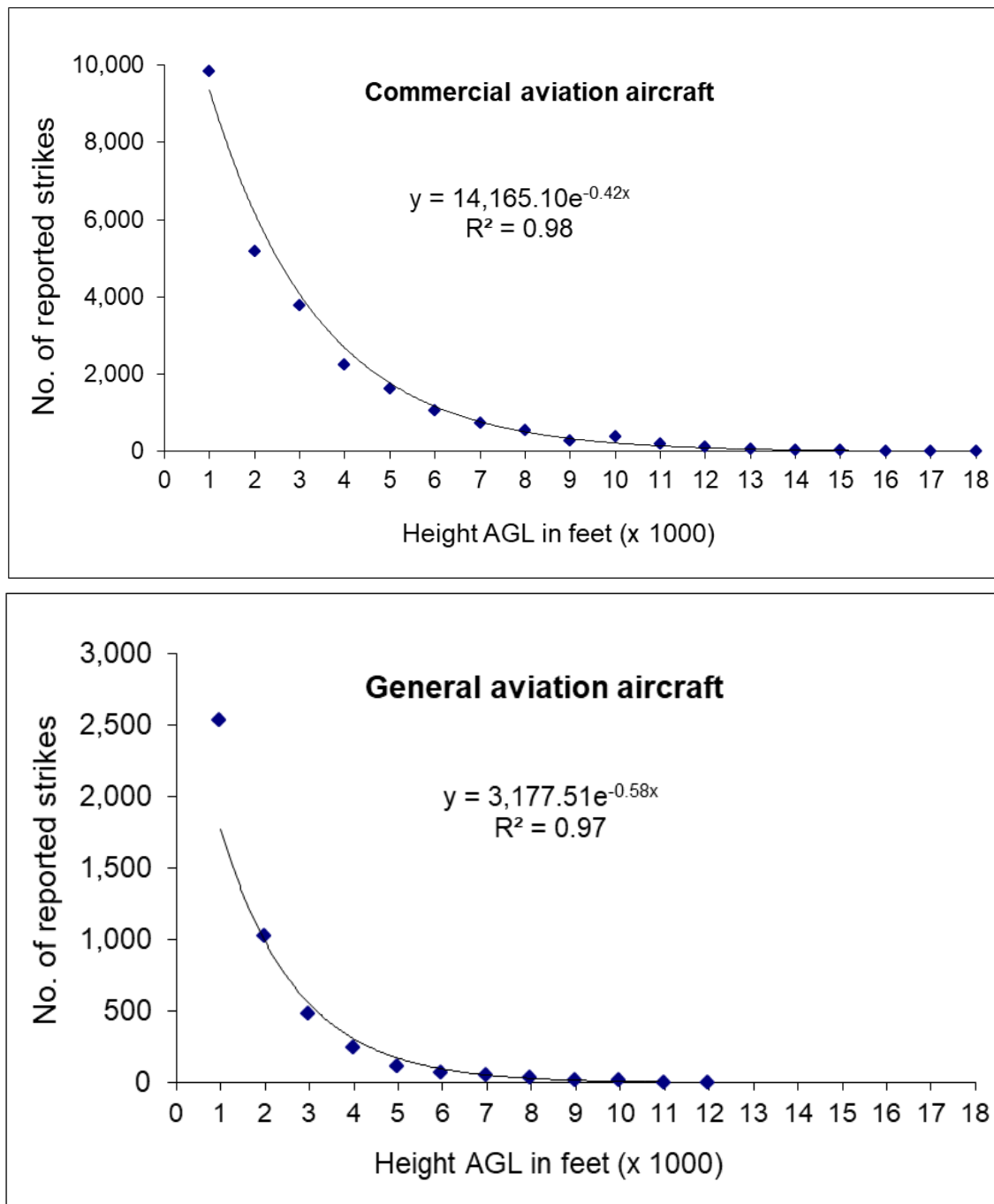


Figure 9. Number of reported bird strikes with commercial (top graph) and general aviation (GA) aircraft (bottom graph) in USA by 1,000-foot height intervals above ground level from 501—1,500 feet (interval 1) to 17,501—18,500 feet (interval 18) for commercial aircraft and to 11,501—12,500 feet (interval 12) for GA aircraft, 1990-2017. These graphs exclude strikes at ≤ 500 feet. Above 500 feet, the number of reported strikes declined consistently by 34 percent and 44 percent for each 1,000 foot gain in height for commercial and GA aircraft, respectively. The exponential equations explained 97 to 98 percent of the variation in number of strikes by 1,000-foot intervals from 501 to 18,500 feet for commercial aircraft and 501 to 12,500 feet for GA aircraft. See Tables 11 and 12 for sample sizes.

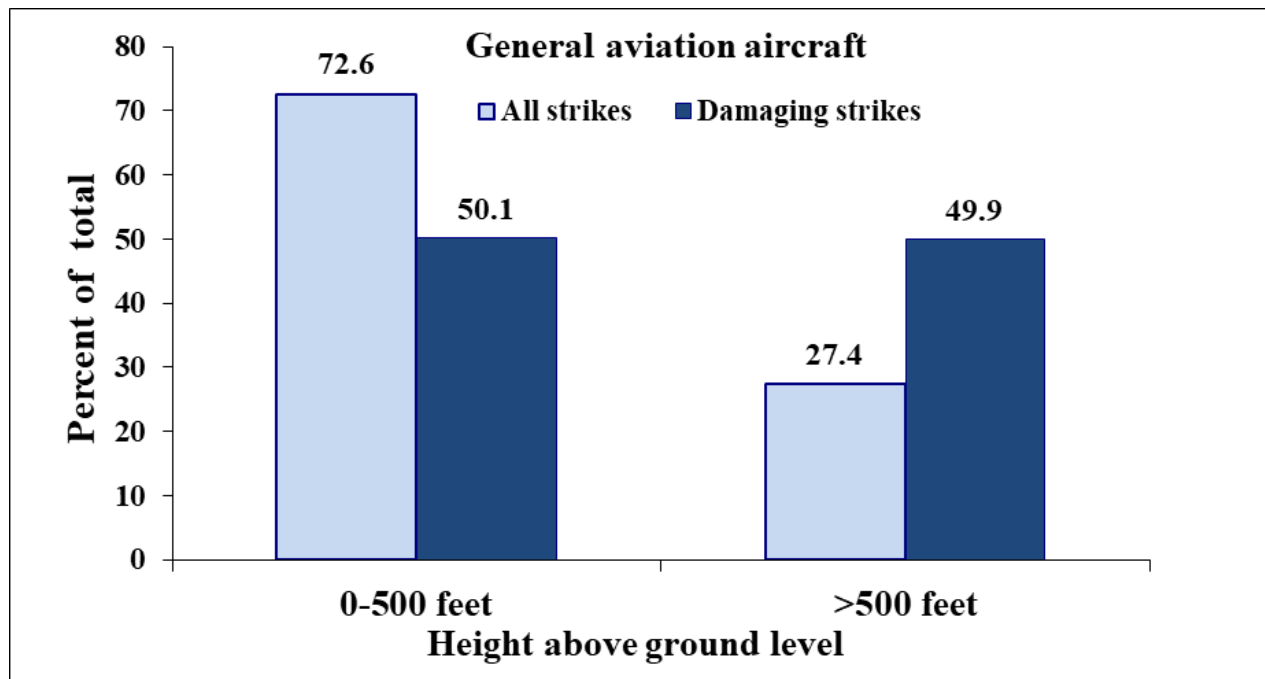
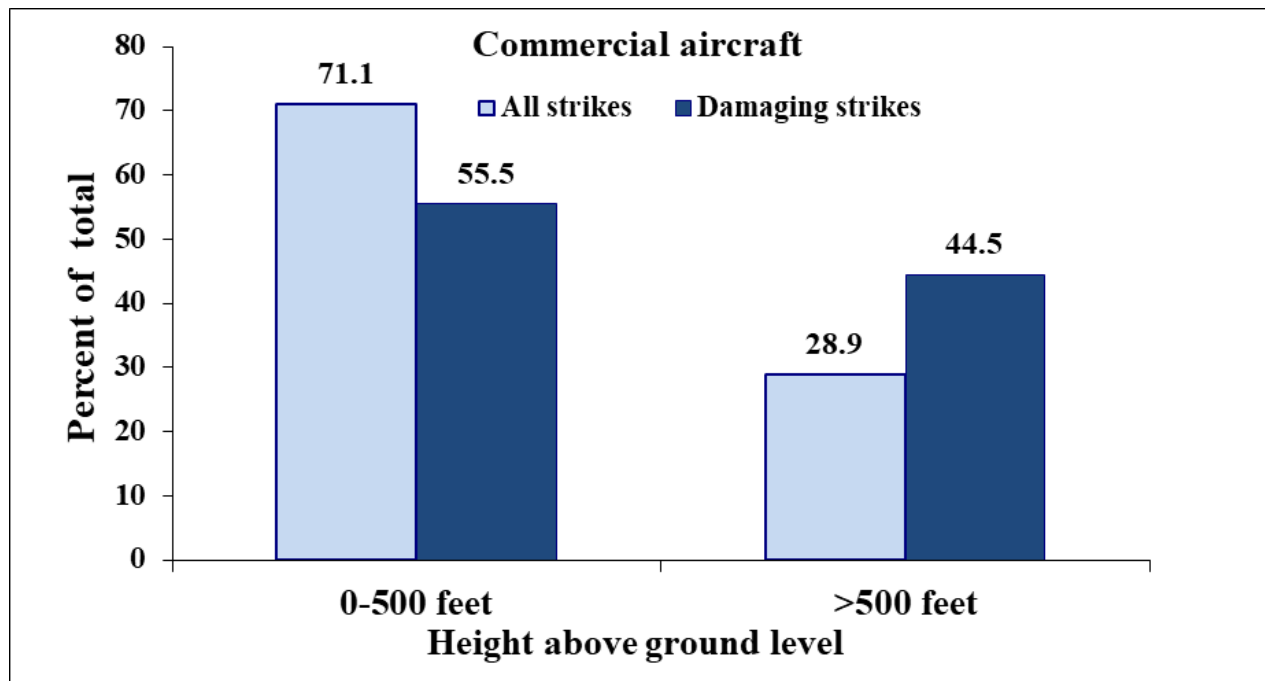


Figure 10. Percentages of total strikes and total damaging strikes occurring at 500 feet or less and above 500 feet for commercial (top graph) and general aviation (bottom graph) aircraft in USA, 1990–2017. See Tables 11 and 12 for sample sizes.

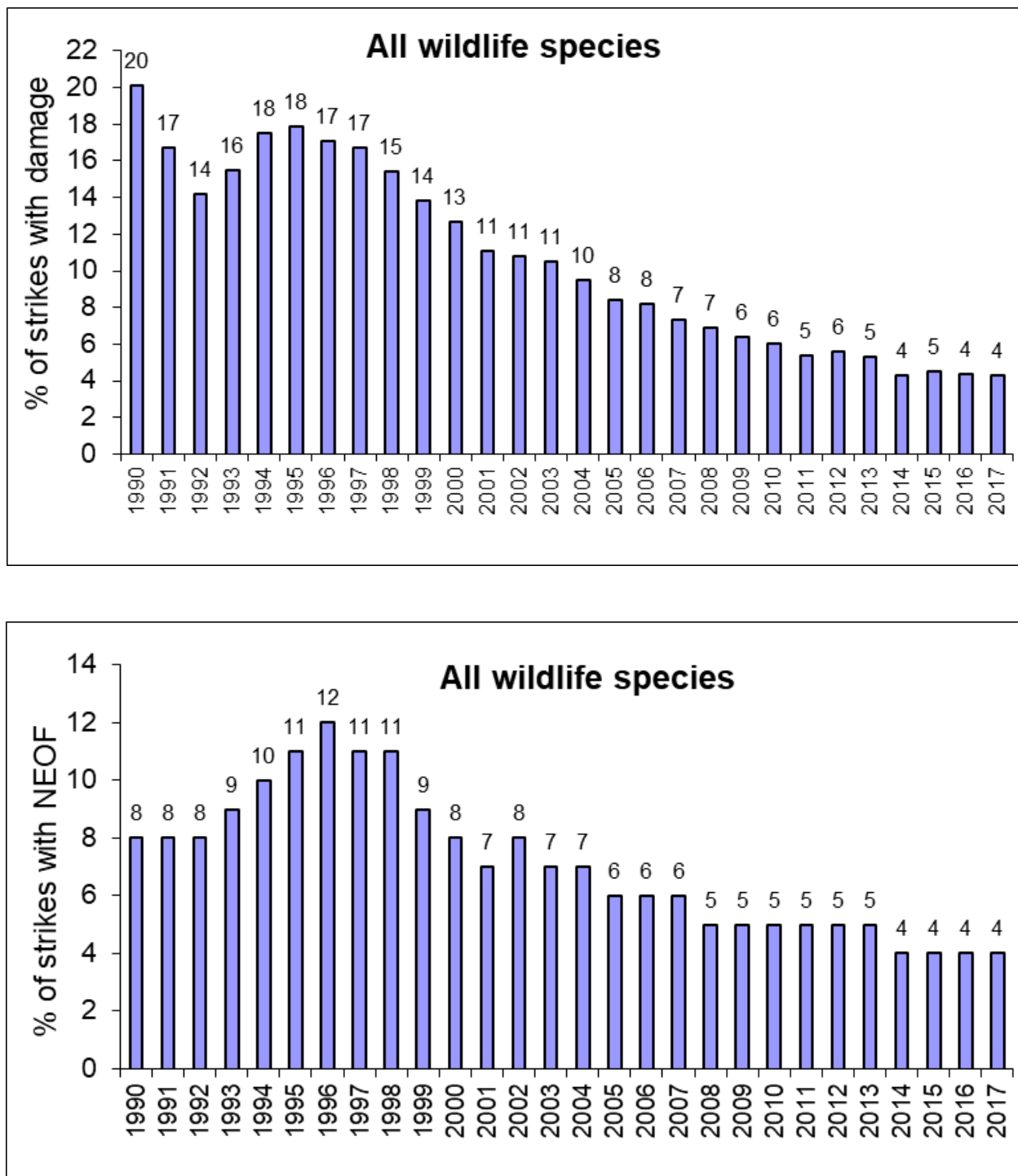


Figure 11. Percentage of reported strikes that indicated damage to the civil aircraft (top graph) or a negative effect-on-flight (NEOF, bottom graph), USA, 1990–2017. See Tables 1, 14, and 15 for sample sizes and classifications of damage and negative effects-on-flight.

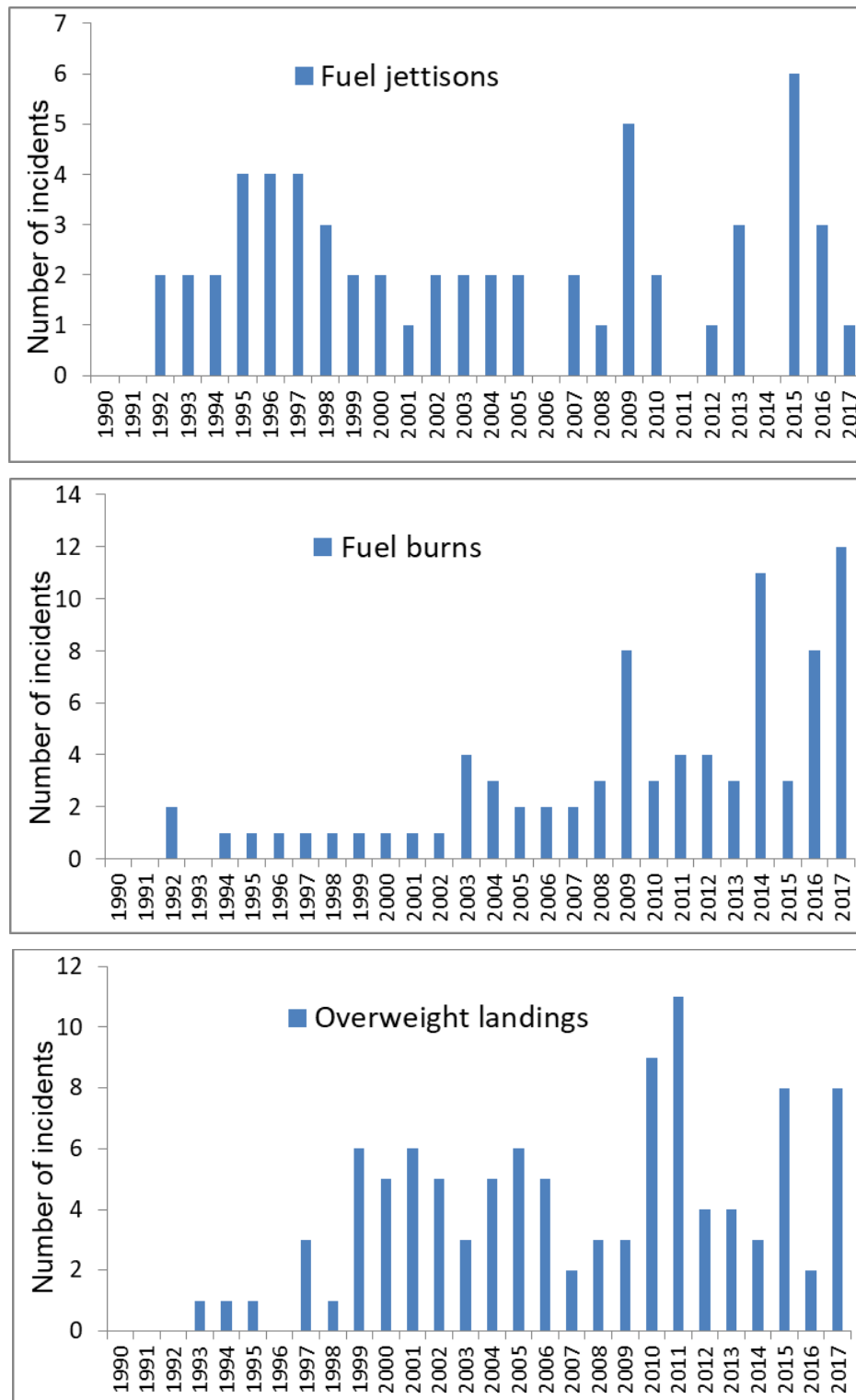


Figure 12. Number of reported incidents where pilot made an emergency or precautionary landing after striking birds during departure in which fuel was jettisoned or burned (circling pattern) to lighten aircraft weight or in which an overweight (greater than maximum landing weight) landing was made (no fuel jettison or burn), USA civil aircraft, 1990–2017. See Table 16 for details on aircraft involved and amount of fuel jettisoned.

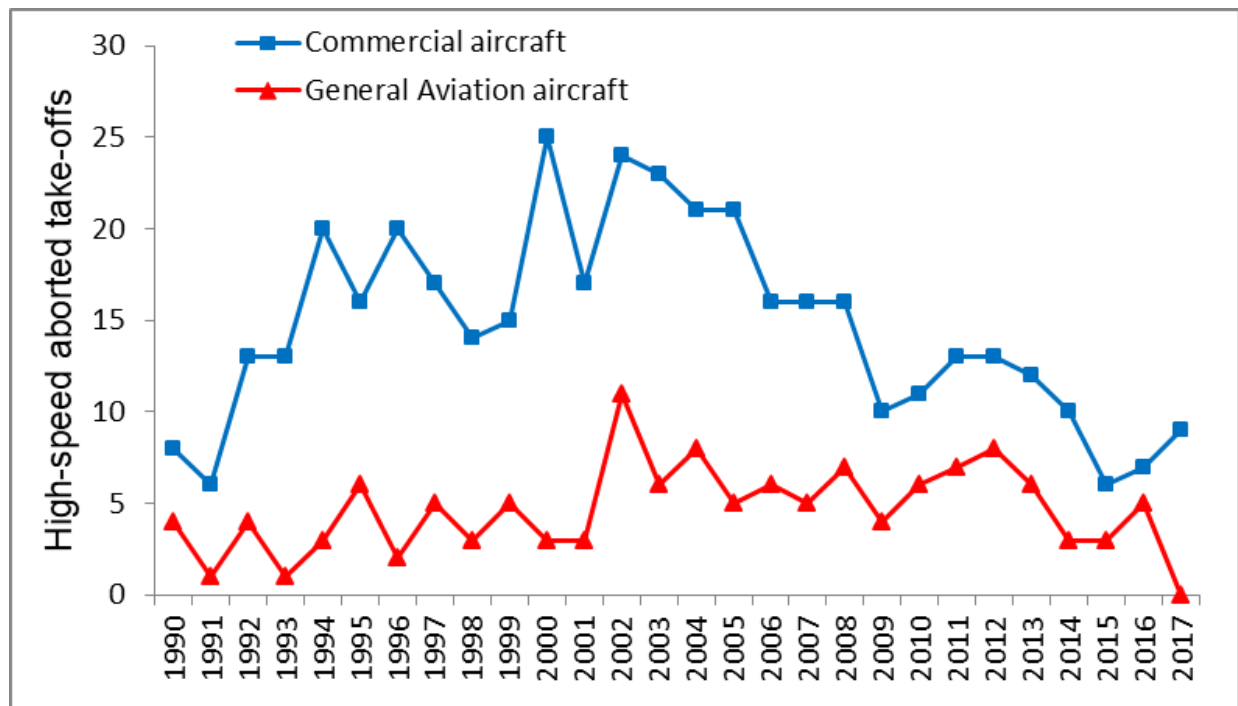


Figure 13. Number of reported incidents in which pilot made an aborted take-off at ≥ 100 knots after striking birds or other wildlife during take-off run, USA civil aircraft, 1990–2017. See Table 17 for classification of aborted take-offs by indicated airspeed.

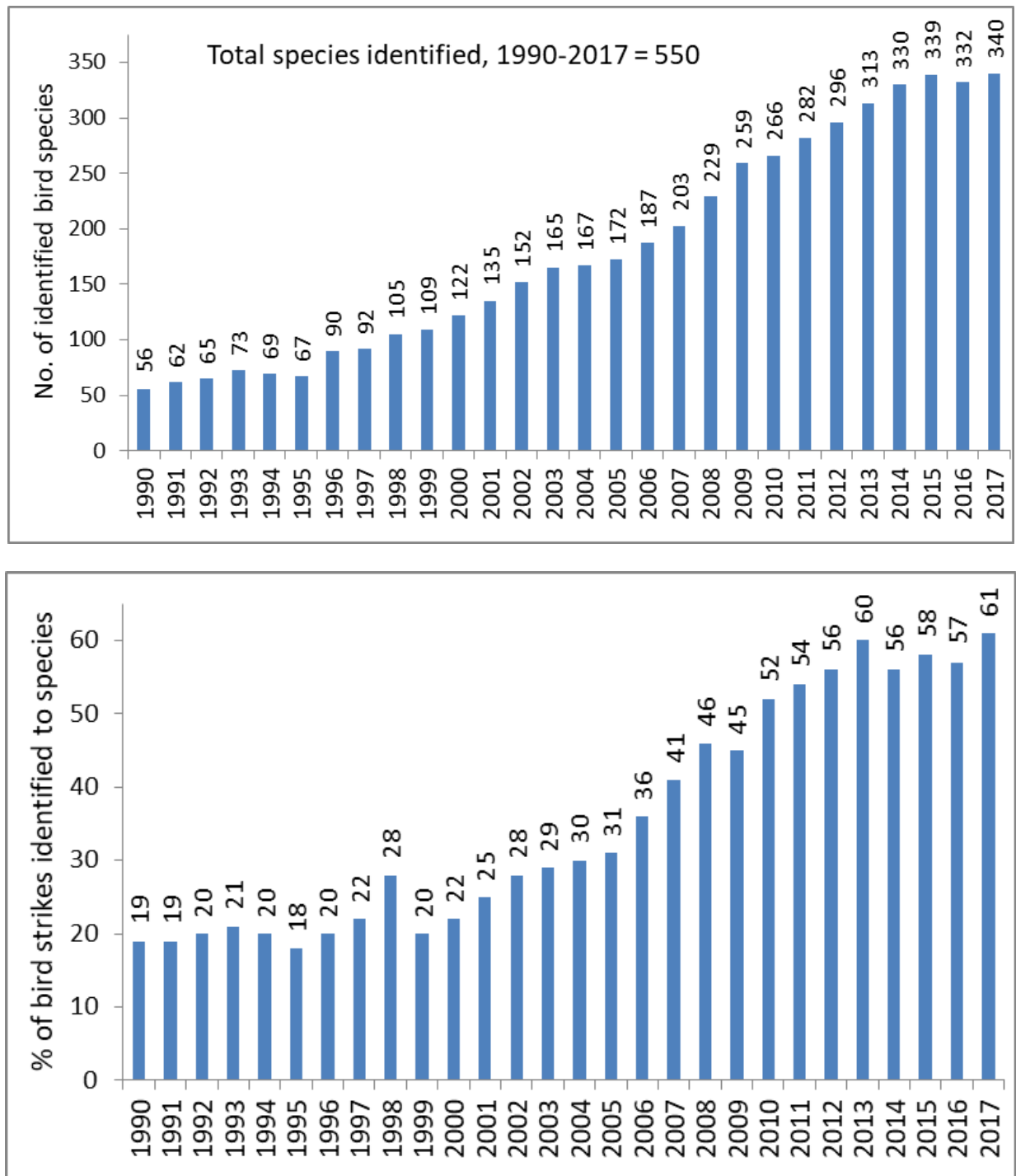


Figure 14. Number of identified bird species struck by civil aircraft each year (top graph) and the percentage of reported bird strikes in which the bird was identified to species (bottom graph), 1990–2017. From 1990 through 2017, 550 different species of birds have been identified. See Tables 1 and 18 for sample sizes and list of species.

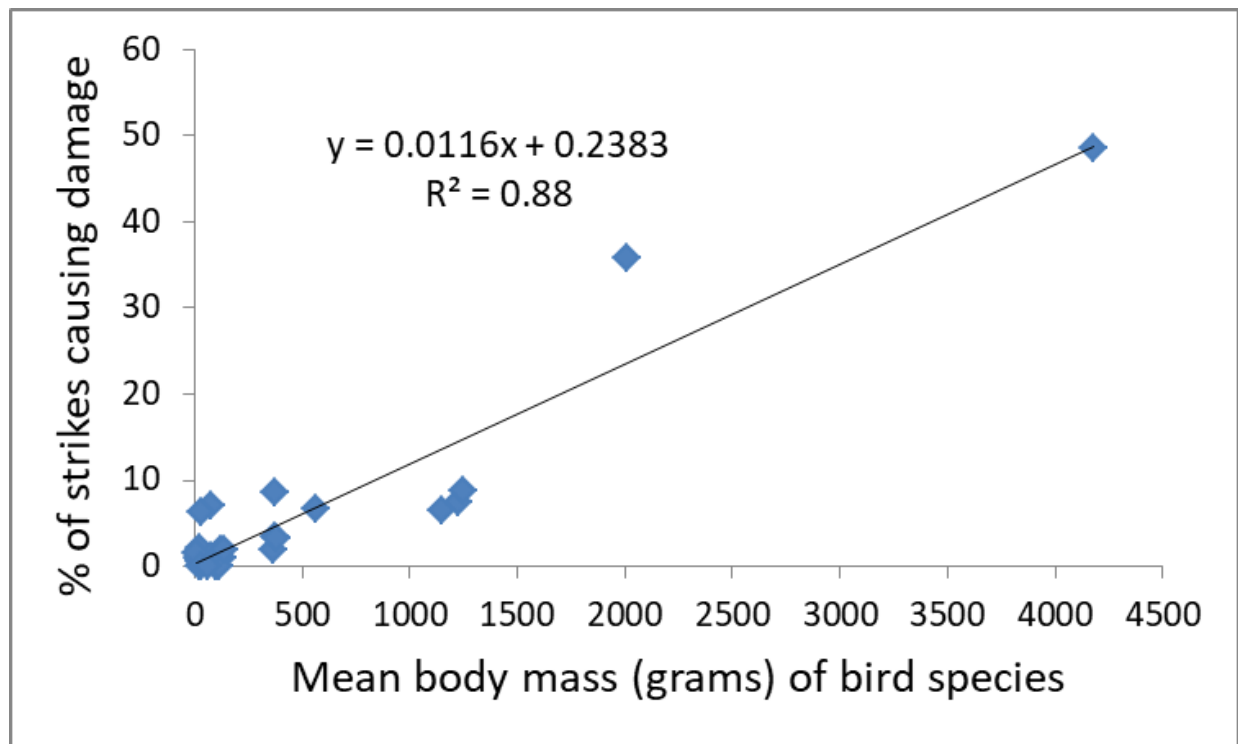


Figure 15. Relation between mean body mass (Dunning 2008) and likelihood of a strike causing damage to aircraft for the 30 species of birds most frequently identified as struck by civil aircraft in USA, 2017 (Table 20). The linear regression equation explained 88 percent of the variation in the likelihood of damage among the 30 species. For every 100 gram increase in body mass, there was a 1.16 percent increase in the likelihood of damage.

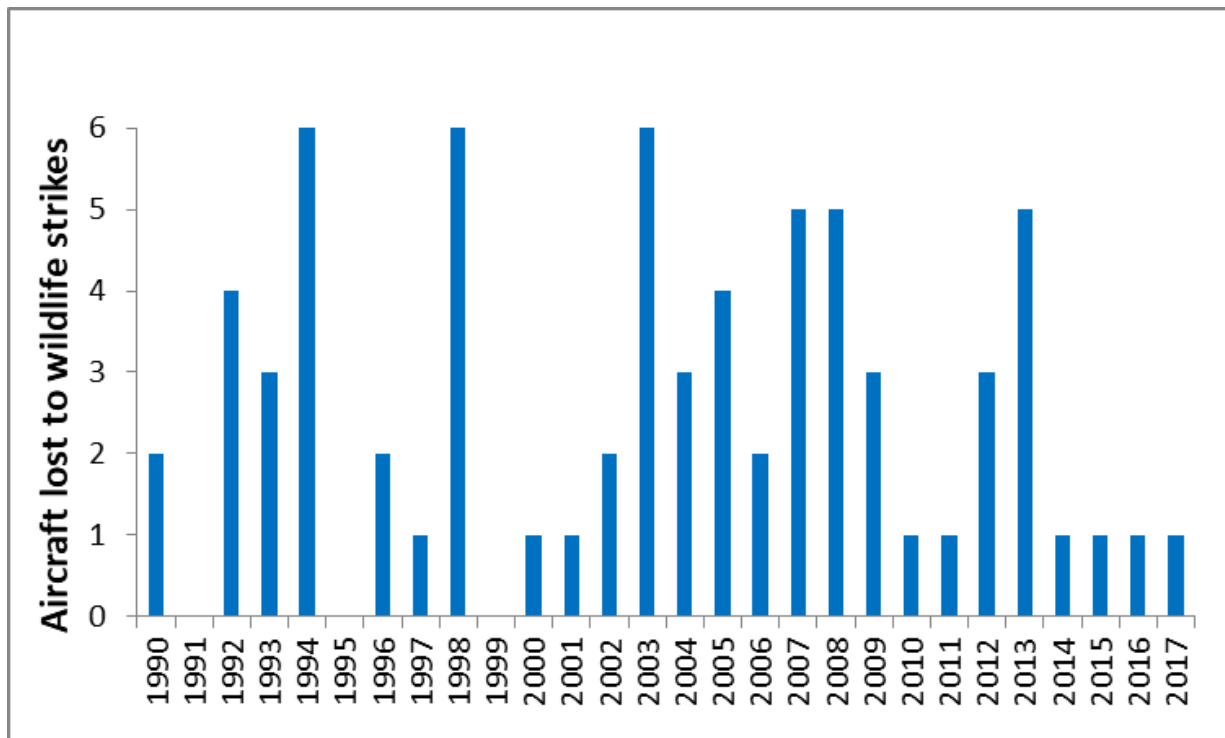


Figure 16. Number of civil aircraft destroyed or damaged beyond repair after striking wildlife, USA, 1990–2017. From 1990 - 2017, 70 aircraft have been lost (45 with maximum take-off mass $\leq 2,250$ kg; 17, 2,251-5,700 kg; 6, 5,701-27,000 kg; 2, $>27,000$ kg). See Table 22 for wildlife species and types of aircraft and airports associated with these events.

APPENDIX A.

SELECTED SIGNIFICANT WILDLIFE STRIKES TO U.S. CIVIL AIRCRAFT, 2017

The U.S. Department of Agriculture, through an interagency agreement with the Federal Aviation Administration, compiles a database of all reported wildlife strikes to U.S. civil aircraft and to foreign carriers experiencing strikes in the USA. From 1990 through 2017, 197,833 strike reports from 2,009 USA airports and 308 foreign airports have been entered in the database (14,496 strikes from 698 USA and 82 foreign airports in 2017 alone, Tables 1, 8; Figure 6). The following 20 examples from the database in 2017 are presented to show the serious impact that strikes by birds or other wildlife can have on aircraft. These examples demonstrate the widespread and diverse nature of the problem. The examples are not intended to highlight or criticize individual airports because, as documented above, strikes have occurred on almost every airport in the USA. Some of the strike examples reported here occurred off airport property during approach or departure. For more information on wildlife strikes or to report a strike, visit www.birdstrike.org and <http://wildlife.faa.gov>.

Date:	13 January 2017
Aircraft:	EC-145
Airport:	(TX)
Phase of Flight:	En Route
Effect on Flight:	None
Damage:	Windshield
Wildlife Species:	Turkey vulture
Comments from Report: Four foot by five foot hole in the left windshield. After controllability and injuries check, continued to receiving hospital and landed without incident. The left seat was unoccupied at the time of the incident and there were no injuries. The bird impacted the windscreen, hit and was almost wrapped in the NVG curtain and ended up between the left rear seat and the door. Bird was deceased on impact.	

Date:	15 February 2017
Aircraft:	CRJ 700
Airport:	Charlotte/Douglas Intl Airport (NC)
Phase of Flight:	Take-off run
Effect on Flight:	Fuel leak, emergency landing
Damage:	Wing
Wildlife Species:	White-tailed deer
<p>Comments from Report: Deer struck right wing of aircraft, damaging leading edge slat and leading edge. Flight crew reported to ATC hearing a loud bang during take-off run and declared that the aircraft would return to the airport for a precautionary landing. ATC was informed by another flight crew on taxi that they witnessed a deer strike. Operations personnel retrieved the remains of 1 deer from the runway. The aircraft returned to KCLT and completed a low pass over runway 36R for inspection for damage and was observed to be leaking fuel from the right wing. The aircraft made an emergency landing, exiting the runway onto taxiway while continuing to leak fuel. ARFF responded and sprayed the area with foam while the aircraft was evacuated. All passengers were returned to the airport terminal via bus. All fuel was drained from the aircraft before it was towed to maintenance for further inspection and repair. Substantial damage was found on the right wing of the aircraft with initial estimated time out of service of 14 days and cost of repair of \$500,000. Flight Crew reported that they did not see deer during take-off run but did feel an impact.</p>	

Date:	19 March 2017
Aircraft:	EMB-175
Airport:	Philadelphia Intl Airport (PA)
Phase of Flight:	Approach
Effect on Flight:	None
Damage:	Engine #2
Wildlife Species:	Ring-billed gull
<p>Comments from Report: Replaced 8 fan blades and other small parts in the engine. At 50 feet AGL above runway 9R, 3 white birds, gull sized flew across runway north to south. The aircraft struck no less than one of the birds with engine #2 cowl and the bird was ingested between 30-50 feet AGL. Thump heard when the bird was struck. Once clear of the runway, ATC notified that we struck a bird over the runway threshold and there might be FOD on the runway. Aircraft time out of service was 27 hours. Repairs reported as \$50,000. ID by Smithsonian, Division of Birds.</p>	

Date:	30 March 2017
Aircraft:	PA-28
Airport:	Tampa Executive Airport (FL)
Phase of Flight:	Take-off run
Effect on Flight:	Aborted take-off
Damage:	Wing, landing gear
Wildlife Species:	Turkey vulture
Comments from Report: Dual instruction flight. Birds were noticed in a resting position late in the take-off run. Two birds were struck after trying to fly away. The take-off was aborted and the aircraft returned to the maintenance department of the school for inspection. Time out of service reported as 10 hours.	

Date:	13 April 2017
Aircraft:	EC-135
Airport:	(IA)
Phase of Flight:	En Route (1,500 feet AGL)
Effect on Flight:	Precautionary landing
Damage:	Windshield
Wildlife Species:	American coot
Comments from Report: Bird struck and penetrated the upper left side of the right windshield (Pilot's side). Struck pilot in left shoulder and continued through aircraft. Struck the rear facing seat in the cabin coming to rest near the right cabin door. Pilot sustained minor bruising of the left shoulder and minor cut from the windshield.	

Date:	17 May 2017
Aircraft:	EMB-190
Airport:	Washington Dulles Intl Airport (DC)
Phase of Flight:	Take-off run
Effect on Flight:	Declared Alert; returned to departure airport; fuel leak
Damage:	Engine #2
Wildlife Species:	Great horned owl
Comments from Report: Damaged engine #2, fan and stator blades, engine outer casing perforated. Aircraft leaked approximately 200 gallons of fuel from damaged engine before flow was mitigated. Airport Ops recovered remains from the departure runway at 5,100 feet remaining. ID by Smithsonian, Division of Birds.	

Date:	1 June 2017
Aircraft:	B-737-900
Airport:	Chicago O'Hare Intl Airport (IL)
Phase of Flight:	Climb (400 feet AGL)
Effect on Flight:	Engine shutdown, Precautionary landing
Damage:	Engine #2
Wildlife Species:	Canada goose
Comments from Report: Pilot reported striking birds shortly after take-off and had to shut down the #2 engine. A stand-by alert called but aircraft landed without incident. Feather and snarge samples taken from 4 locations of the aircraft. All 4 locations were identified as Canada goose. Pilot reported seeing a flock of geese before the strike occurred. Time out of service reported as 40 hours. Reported repairs \$1.5 million. ID by Smithsonian, Division of Birds.	

Date:	19 July 2017
Aircraft:	Weatherly 620A
Airport:	Pemberton Airport (NJ)
Phase of Flight:	Climb (10 feet AGL)
Effect on Flight:	Forced landing
Damage:	Propeller
Wildlife Species:	Canada goose
Comments from Report: One of the three propeller blades took impact of the birdstrike. Propeller blade pitch control arm and pin were separated and blade rotated 180 degrees causing severe loss of propeller thrust and lift. Forced landing resulted in substantial aircraft damage. No injuries or other property damage. Reported repairs and other costs \$75,000.	

Date:	28 July 2017
Aircraft:	B-737
Airport:	Deadhorse Airport (AK)
Phase of Flight:	Approach
Effect on Flight:	Go-around
Damage:	None
Wildlife Species:	Caribou
Comments from Report: The pilot saw the caribou just prior to touch down and initiated a go-around. The caribou was struck by the landing gear and perished. There were 100 pax and 5 crew onboard with no injuries.	

Date:	5 August 2017
Aircraft:	Stoddard-Hamilton Glasair II
Airport:	(CA)
Phase of Flight:	En Route
Effect on Flight:	Declared emergency; precautionary landing; fuel leak
Damage:	Fuel tank
Wildlife Species:	Unknown bird
Comments from Report: Diverted and declared an emergency due to reported birdstrike. Minor damage.	

Date:	30 August 2017
Aircraft:	PA-31-350
Airport:	Rota Intl Airport (U.S. Commonwealth of N. Mariana Islands)
Phase of Flight:	Climb (150 feet AGL)
Effect on Flight:	Partial gear up landing
Damage:	Landing gear, wing
Wildlife Species:	Unknown medium-sized bird
Comments from Report: Shortly after takeoff and while the landing gear was being retracted the pilot reported hearing unusual sounds similar to impact and observed a flock of 10-20 medium sized birds. The aircraft sustained a dent in the left wing inboard the leading edge and a gear malfunction that prevented the gear from fully retracting. The aircraft landed with the right main gear extended but unlocked, left main gear and nose gear retracted, both main gear inboard doors were extended. Time out of service reported as 4000 hours. Reported repairs \$80,000.	

Date:	7 September 2017
Aircraft:	Cessna 510
Airport:	Danbury Municipal Airport (CT)
Phase of Flight:	Approach (120 feet AGL)
Effect on Flight:	Engine shutdown
Damage:	Engine #2
Wildlife Species:	Canada goose
Comments from Report: Short final approximately 0.5 miles to runway 26 threshold. Struck several geese ingesting at least one into the right engine. Pilot reported right engine immediately "shut down". Landed without further incident and taxied to ramp. Upon inspection, right engine appears to be severely damaged with remains of goose still lodged in the engine. The right gear door and right fuselage near engine show signs of blood but no visible damage. Time out of service reported as 14 hours. Reported repairs and other costs \$750,000.	

Date:	12 September 2017
Aircraft:	OH-58C
Airport:	(FL)
Phase of Flight:	En Route (450 feet AGL)
Effect on Flight:	Precautionary landing
Damage:	Windshield
Wildlife Species:	Gull
<p>Comments from Report: Number two in flight of two aircraft; VFR flight plan assigned by ATC to at/or below 500 feet in communication with Eglin AFB approach. Flight was east bound over water following coast line in Eglin/Valparaiso terminal area (east-west corridor). Pilot windscreen (right side) struck by gull, windscreen shattered, bird entered cockpit striking right door emergency jettison handle, ejecting door into Gulf waters. Bird continued rearward striking pilot on top of helmet and then falling to floor at pilot's feet, dead. No injury to pilot. Helmet sent to vendor for inspection, no visible signs of damage to helmet. Lead aircraft made call that number two aircraft sustained a bird strike and needed to make immediate landing, Eglin approach advised Destin (KDTS) was 1.5 miles to left and flight proceeded to airport and made safe landing. Visual inspection of aircraft revealed only right windscreen shattered, no other damage noted at that time. Reported repairs and other costs \$12,000.</p>	

Date:	16 September 2017
Aircraft:	Vans RV8
Airport:	Nehalem Bay State Airport (OR)
Phase of Flight:	Approach
Effect on Flight:	Ground loop
Damage:	Landing gear, wing
Wildlife Species:	Elk
<p>Comments from Report: Aircraft had just touched down when an elk ran in front of the plane. Pilot tried to speed up and relaunch in an attempt to fly over the elk. Landing gear and propeller struck the elk. An instant later, a second elk ran in front of the aircraft and struck the left wing. Aircraft ground looped twice. Substantial damage.</p>	

Date:	25 October 2017
Aircraft:	C-17A
Airport:	Kelly Field Airport (TX)
Phase of Flight:	Climb (800 feet AGL)
Effect on Flight:	Engine shutdown
Damage:	Engine #4
Wildlife Species:	Turkey vulture
<p>Comments from Report: Shortly after takeoff, in a turn to heading 210 as assigned by ATC, a large turkey vulture impacted the #4 engine. All 3 crewmembers in cockpit made visual contact with the bird but too late for evasive maneuver. Aircraft was just northwest of Wilford Hall Medical Center on Lackland AFB. The crew could feel, hear and smell the bird's impact. Immediately the engine began to vibrate and the throttle was retarded to idle. Subsequently, the crew ran the Engine Shutdown InFlight Checklist, Landing With One or More Engines Inop Checklist, 3 Engine Go-Around Checklist and all normal checklists. Visual confirmation of no fire, leaks and outside damage was confirmed by the loadmaster. Aircrew declared an emergency and requested vectors to a visual approach to runway 34. Landing at KSKF was uneventful. Reported repairs \$15 million.</p>	

Date:	5 November 2017
Aircraft:	Bell 407
Airport:	Gulf of Mexico (20 miles E of KGAO)
Phase of Flight:	En Route (750 feet AGL)
Effect on Flight:	Precautionary landing on oil rig
Damage:	Windshield
Wildlife Species:	Brown pelican
<p>Comments from Report: Rotorcraft en route to oil rig. Bird shattered the windscreen. Landed without incident on oil rig MP281, off the coast of Galliano, LA. Note: Pilot reported that bird was "believed to be a pelican"; flight behavior of bird flock as described by pilot resembled that of brown pelicans. Assume brown pelican based on pilot report and location. No remains were collected.</p>	

Date:	18 November 2017
Aircraft:	C-172M
Airport:	(CA)
Phase of Flight:	En Route (3,300 feet AGL)
Effect on Flight:	Declared emergency landing
Damage:	Windshield
Wildlife Species:	Greater white-fronted goose
<p>Comments from Report: Occurred at night. Windshield destroyed. Cockpit exposed to flight environment. Minor injuries to 2 of the occupants. Time out of service reported as 5 hours. Reported repairs and other costs total \$7,100.</p>	

Date:	19 November 2017
Aircraft:	Bell 407
Airport:	Near Stuttgart (AR)
Phase of Flight:	En Route (1,040 feet AGL, 116 knots)
Effect on Flight:	Crash
Damage:	Helicopter destroyed (3 fatalities)
Wildlife Species:	Snow goose
Comments: Medical transport helicopter struck several snow geese while en route at night to pick up patient. Burned wreckage was found several hours later next to reservoir containing large numbers of waterfowl. Bird remains were found in helicopter at wreckage site. ID by Smithsonian, Division of Birds.	

Date:	4 December 2017
Aircraft:	A-320
Airport:	Sacramento Intl Airport (CA)
Phase of Flight:	Climb (1,000 feet AGL)
Effect on Flight:	Declared emergency landing
Damage:	Nose, engine #1, engine #2, wing
Wildlife Species:	Snow goose, Ross's goose
Comments: Pilots stated they had just reached 1,000 feet AGL when they encountered a flock of birds and had multiple birdstrikes. Upon inspection, there was evidence of ingestion and damage to both engines as well as damage to the left wing slats and nose of the aircraft. Airport biologist found 12 carcasses (11 snow geese and 1 Ross's goose).	

Date:	4 December 2017
Aircraft:	C-402
Airport:	Barnstable Municipal Airport (MA)
Phase of Flight:	Climb (800 feet AGL)
Effect on Flight:	Declared emergency landing, obscured vision
Damage:	Radome, windshield, nose, wing
Wildlife Species:	Canada goose
Comments: ID by Smithsonian, Division of Birds is pending. The aircraft windshield was damaged. Dent on right side of nosecone/radome. Minor damage to the right wing. Time out of service reported as 504 hours. Reported repair and other costs total \$25,000. ID by Smithsonian, Division of Birds	

APPENDIX B.

REPORTING A STRIKE AND IDENTIFYING SPECIES OF WILDLIFE STRUCK

Pilots, airport operations, aircraft maintenance personnel, and anyone else having knowledge of a strike should report the incident to the FAA using FAA Form 5200-7. Strikes can be reported electronically via the internet (<http://wildlife.faa.gov>) or Form 5200-7 can be accessed and printed for mailing in reports.

It is important to include as much information as possible on FAA Form 5200-7. All reports are carefully screened to identify duplicate reports prior to entry in the database. Multiple reports of the same incident are combined and often provide a more complete record of the strike event than would be possible if just one report were filed.



The National Museum of Natural History, Smithsonian Institution, has the 3rd largest bird collection in the world with over 640,000 specimens. The collection has representatives of about 80% of the 9,600 known species in the world's avifauna.

The identification of the exact species struck (e.g., ring-billed gull, Canada goose, mallard, mourning dove, or red-tailed hawk as opposed to gull, goose, duck, dove, or hawk) is particularly important. This species information is critical for biologists developing wildlife risk management programs at airports and for engineers working on airworthiness standards because a problem that cannot be measured or defined cannot be solved. Bird strike remains that cannot be identified by airport personnel can often be identified by a local biologist trained in ornithology or by sending feather and other remains in a sealed plastic bag (with FAA Form 5200-7) to:

Material sent via Express Mail Service:	Material sent via U.S. Postal Service:
Feather Identification Lab Smithsonian Institution NMNH E600, MRC 116 10 th & Constitution Ave. NW Washington, D.C. 20560-0116 (label package "safety investigation material") Phone #s 202-633-0787 or 202-633-0791	Feather Identification Lab Smithsonian Institution, NMNH E600, MRC 116 P.O. Box 37012 Washington, D.C. 20013-7012 (not recommended for priority cases)

The number of bird strike cases processed by the Smithsonian Feather Identification Lab for the FAA (civil aviation) in 2017 was 3,826 with 4,156 separate identifications of species (some cases involved remains from multiple impact points). This compares to 3,670

cases in 2016, and 3,118 cases in 2015 (Dove et al. 2018). In addition, the Lab processed 3,665 cases involving 4,598 identifications for the U.S. Air Force and 772 cases involving 856 identifications for the U.S. Navy in 2017 (not discussed in this report). DNA analysis (Dove et al. 2008) was used in 2,574 (62 percent) of all identifications for civil aviation to identify, supplement, or verify traditional identification methods.

Whenever possible, reporters should send whole feathers as diagnostic characteristics are often found in the downy barbules at the feather base. Wings, as well as breast and tail feathers, should be sent whenever possible. Beaks, feet, bones, and talons are also useful diagnostic materials. Even blood smears can provide material for DNA analysis (Dove et al. 2008). **Do not send entire bird carcasses through the mail!** However, photographs of the carcasses can be useful supplemental documentation.

Guidelines for Collecting Bird Strike Material

- Always include any feather material available.
- Include copy of report (FAA 5200-7).
- Always secure all remains in re-sealable plastic bag.

Feathers:

Whole Bird – Pluck a variety of feathers (breast, back, wing, tail)

Partial Bird – Collect a variety of feathers with color or pattern

Feathers only – Send all material available. Do not cut feathers from the bird (downy part at the base of the feathers is needed). Do not use any sticky substance (no tape or glue).

Tissue/blood (“Snarge”):

Dry material – Scrape or wipe off into a clean re-closeable bag **or** wipe area with pre-packaged alcohol wipe **or** spray with alcohol to loosen material then wipe with clean cloth/gauze. (Do not use water, bleach, or other cleansers; they destroy DNA.)

Fresh material – Wipe area with alcohol wipe and/or clean cloth/gauze **or** apply fresh tissue/blood to an FTA® DNA collecting card.

FTA® Micro Card and Sterile Applicators

If you send a lot of fresh blood/ tissue samples for DNA identification, you may want to consider getting Whatman FTA® DNA cards. The material is sampled with a sterile applicator and placed onto the surface of the card that “fixes” the DNA in the sample. For more information on ordering these items contact the Feather Lab.

Note: If you only occasionally send blood/ tissue samples, a paper towel with alcohol or alcohol wipe is still a good option for this type of material.

Additional information on sending bird remains to the Smithsonian is available at <http://wildlife.faa.gov>.